Essays in Development Economics

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Abstract

This dissertation comprises three essays in development economics.

Chapter One studies how constraints on the political power of elites shape economic and social life. In Sierra Leone, we document that areas in which chiefs face less political competition have significantly worse development outcomes today—in particular, lower rates of educational attainment, child health, non-agricultural employment and asset ownership. Paradoxically, we also show that in chiefdoms with less competition the institutions of chiefs' authority are more highly respected among villagers, and measured social capital is higher. We argue that these results reflect the capture of civil society organizations by chiefs.

Chapter Two develops a new "spatial Lewis model" of industrialization across space in order to study a policy of the Indian government that reallocated capital to less developed regions of the country that nonetheless had large populations. The model emphasizes that even with constant agglomeration economies across space, capital investment may have a higher social return in areas where labor can be brought in to complement it at cheaper rates. In light of the model, such redistributive policies as those of the Indian government can be seen to be welfare improving in the aggregate.

Chapter Three studies the cocoa sector of Sierra Leone, where it is common for farmers and traders to engage in interlinked transactions in which output prices are determined jointly with the terms of a credit contract. We study price-pass thorough in the presence of such interlinkages. In response to an increase in a trader's wholesale price, we find limited pass-through of the price to farmers. However we also find a large increase in the likelihood that traders provide credit to farmers, suggesting that the value of the wholesale price increase was passed to farmers along a different margin. These results, upon which we build a model to provide intuition, suggest that

the presence of interlinkages is a candidate explanation for low rates of price pass-through that have been observed, but one with substantially different implications for welfare than others.

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Acknowledgments

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To everyone in Sierra Leone who is trying.

Introduction

I have always been uncomfortable with the term development. It implies progress to some better and more perfect condition. In principal, development economists make their living measuring quantitative indicators of this progress—output per capita, financial sector development, health and so fourth—but the discipline itself has surprisingly little to say about what it is they indicate progress towards. Georg W.F. Hegel summarizes this problem succinctly in his discussion of the development of the spirit, surely something close to what we are reaching for when we speak of economic development:

> “The object in hand, the qualitative element, is given from the start, but no indication is given of the goal which is supposed to be ultimately reached; the goal itself remains completely indefinite. If however, we wish to discuss progress in definite terms, we must realize that the idea of quantitative change is devoid of intellectual content. We must know the goal which is supposed to be ultimately attained, because the activity of the spirit is such that its productions and changes must be presented and recognized as variations in quality.” (Hegel, 1830, pg. 126)

Even as the profession has coalesced, I believe, around the definition of the goal of development provided by Sen (1999), who, much in the spirit of Hegel, defines development as freedom or the capability people have to realize their potential, this definition itself says little about how one achieves this freedom, and moreover how to measure quantitatively when and where it has been achieved. Even once we have the goal, it is still a challenge to link quantitative indicators to it. All of this faces the student of development economics with a difficult question: If we truly care about the betterment of the spirit, what indicators and processes do we study? To find the topics for three essays in development economics is no easy task.

My discomfort with the term comes not just from its ambiguity, but also with the particular role it plays in society. The work and writings of development economists shape what Escobar

(1995, pg. 39) calls the development discourse, “a space in which only certain things could be said and even imagined.” In choosing what we mean by development, we also define both the identities and needs of “the poor,” often without allowing them to speak for themselves. The development economist is then in the very awkward position of speaking of the goals and aspirations of people who, for lack of political voice, cannot speak out if he or she is wrong.

The span of topics across the three essays in this dissertation reflects my attempts to study the means to the end of greater freedom, which following Sen I have taken to be the goal. In these essays, I have sought to be sensitive to the role played by the development discourse, and have tried not to speak for the people of the two “developing countries,” I study, Sierra Leone and India, but rather to understand how they themselves seek to achieve certain outcomes that we can speak of positively as signs of development. The goal of my research has been to show how societies using their own institutions have come to improve (or diminish) their own capabilities.

Chapter One, set in Sierra Leone, studies how local political institutions affect development. My co-authors and I use the colonial organization of chieftaincy in Sierra Leone to study the effect of constraints on chiefs’ power on economic outcomes, citizens’ attitudes and social capital. There, a paramount chief must come from one of the ruling families originally recognized by British colonial authorities. Chiefs face fewer constraints and less political competition in chiefdoms with fewer ruling families. We show that places with fewer ruling families have significantly worse development outcomes today—in particular, lower rates of educational attainment, child health, non-agricultural employment and asset ownership. We present evidence that variation in the security of property rights in land is a potential mechanism. Paradoxically we also show that in chiefdoms with fewer ruling families the institutions of chiefs’ authority are more highly respected among villagers, and measured social capital is higher. We argue that these results reflect the capture of civil society organizations by chiefs. The extent of political competition within a society can affect both economic and social life.

Chapter Two, set in India, studies how and whether one should use targeted investment to promote the growth of the wage bill in poor areas of a country which may still have large population. In it, I have tried to synthesize a policy debate, still quite current within the country, about how much government should distort the allocation of capital across space. I study the removal of industrial licenses in India that restricted the ability of capital to move to places, such as urban areas, in which production would have otherwise naturally agglomerated. While the reforms increased welfare in urban areas, as measured by the formal sector wage bill, by allowing capital to accumulate more rapidly there, welfare, by the same measure, fell in rural areas. These results are interpreted in the context of a new "spatial Lewis model" of industrialization across space, which I believe captures the spirit of the policy debate in India. The model emphasizes that even with constant agglomeration economies across space, capital investment may have a higher social return in areas where labor can be brought in to complement it at cheaper rates. Viewed in this light, policies to reallocate capital across space in India may well have been welfare improving.

Chapter Three, set again in Sierra Leone, studies the nature of trading relationships in the agricultural sector, and how traders and farmers work to overcome the absence of formal financial institutions. In particular it studies the role of traders as creditors. Interlinked transactions in which output prices are determined jointly with the terms of a credit contract are an important feature of many business relationships, particularly in developing economies. With my co-author, I present results from a randomized experiment designed to study how value is passed along the agricultural supply chain in the presence of such interlinkages. In response to an increase in a trader's wholesale price, we find limited pass-through of the price to farmers. However we also find a large increase in the likelihood that traders provide credit to farmers, suggesting that the value of the wholesale price increase was passed to farmers along a different margin. We develop a model of interlinked transactions that shows how price and credit pass-through are determined, and verify its predictions empirically. Our work suggests that the presence of interlinkages is a candidate explanation for low rates of price pass-through that have been observed, but one with substantially different implications for welfare than others.

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Chapter 1

Chiefs: Economic Development and Elite Control of Civil Society in Sierra Leone[1]

1.1 Introduction

The social science literature on African development has identified the weakness of institutional constraints that prohibit the abuse of state power as a potent cause of poor governance and low growth in Africa at the national level (for example Bates, 1981, Sandbrook, 1985, Bayart, 1993, Young, 1994, Herbst, 2000, and the essays in Ndulu, O'Connell, Bates, Collier, Soludo eds., 2007). In a predominantly rural continent, where the reach of the central state is often short, the lack of accountability at the local level may be just as important. The lowest layer of government in most sub-Saharan African (henceforth African) countries is occupied by traditional rulers, or 'chiefs'. Chiefs raise taxes, control the judicial system, and allocate land, the most important resource in rural areas.[2] Despite their central role in African society, relatively little is known about how

[1]Co-authored with Daron Acemoglu and James Robinson; forthcoming in the *Journal of Political Economy*, April 2014, Vol. 122, No. 2.

[2]Logan (2011) illustrates this power of chiefs using the AFRObarometer survey from Benin, Botswana, Burkina Faso, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mozambique, Namibia, Nigeria, Senegal, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe. Despite many of these countries having introduced elected local governments, 50% of respondents report that traditional leaders have "some" or "a great deal" of influence in governing their local community. Traditional authorities are often the primary institution regulating matters of importance for local economic growth, raising taxes, mediating disputes and allocating land. They also have influence over many categories of expenditures on local public goods such as schools and the maintenance of infrastructure. In Ghana, Malawi, Zimbabwe, Lesotho, Zambia and Mali, more than 30% of respondents report that traditional leaders have the primary responsibility for allocating land. In Lesotho, Botswana, Ghana, Malawi, Kenya, Zimbabwe, Mali, Zambia, and

chiefs exercise their political and economic power, how (and whether) they are accountable to their communities, and the effects of constraints on their power on economic development.

In this paper, we use the colonial organization of the chieftaincy in Sierra Leone to study the impact of constraints on chiefs' power on economic outcomes, citizens' attitudes and social capital. In 1896 British colonial authorities empowered a set of paramount chiefs as the sole authority of local government in the newly-created Sierra Leone Protectorate. The paramount chiefs and the sub-chiefs and headmen under them remained effectively the only institution of local government until the World Bank sponsored the creation of a system of elected local councils in 2004. These paramount chiefs are elected for life by a 'Tribal Authority' made up of local notables. Only individuals from the designated 'ruling families' of a chieftaincy — the elite created and given exclusive right to rule by the British at the initiation of the system in 1896 — are eligible to become paramount chiefs.

We hypothesize that the greater the number of ruling families in a chieftaincy, the greater the extent of political competition and the more constraints will be placed on the power of a ruling chief. As Murphy (1990) describes in his study of the Mende of southern Sierra Leone, in the years leading up to a chief's death families form complex alliances with one another in order to secure votes from the Tribal Authority in the upcoming election. Gaining support at all levels of local politics, from the paramount chief to the village headman, "necessitates forming complex coalitions. Competitive agnates [descendants from the same male line] ally with members of rival lineages at the same political level or with lineages at higher or lower levels to gain support for their intralineage power struggles" (p. 29). With more ruling families, a successful candidate will have to satisfy a greater plurality of interests to be elected. Even if one family is able to dominate the chieftaincy for many generations, with more ruling families there will be a greater potential for the incumbent to lose the paramount chieftaincy in an election. This creates a powerful threat that will discipline paramount chiefs, forcing them to govern better.

We further hypothesize, following Becker (1958), Stigler (1972) and Wittman (1989), that the greater competition brought about by more ruling families will promote efficiency (or restrict the

Senegal, more than 30% of respondents report that traditional leaders have the primary responsibility for resolving local conflict.

distortions following from the unchecked power of chiefs).[3] For example, chiefs constrained by greater competition will be less able to manipulate access to land for their own benefit or will have to compete by offering and providing public goods, in the same way that political parties or lobbies constrained by competition are (as in the model of Lizzeri and Persico, 2004).

To measure the number of families, we conducted a survey in 2011 of 'encyclopedias' (the name given in Sierra Leone to elders who preserve the oral history of the chieftaincy) and the elders in all of the ruling families of all 149 chieftaincies. While the government maintains no official list of families, there is broad agreement within chiefdoms about the identity and number of families. We used the survey to re-construct the history of the chieftaincy for as far back as our respondents could recall. This history included the names of the paramount chiefs, which ruling family they were from, and when available, the dates they were elected. We also collected information on the origins of the chieftaincy and of each of the ruling families. We used the archives of the Sierra Leone National Archive situated at Fourah Bay College, as well as Provincial Secretary archives in Kenema, the National Archives in London and available secondary sources to cross-check the results of our survey whenever possible. To the best of our knowledge, we are the first to have constructed a comprehensive history of the chieftaincy in Sierra Leone.[4]

Clearly, the number of ruling families in a chieftaincy may be correlated with omitted variables that influence current development and social outcomes through other channels. We use three strategies to alleviate this concern. First, we study the history of the ruling families in a sample of six chieftaincies, documenting that their origins are highly heterogenous and often the result of historical accident, such as the availability of a male heir or the number of leaders in an invading war party. Second, we show that the number of ruling families is uncorrelated with the level of development before the creation of paramount chiefs as measured by tax assessments per

[3]There are only a few studies estimating the relationship between political competition and various economic outcomes. Most studies use the margin of victory in plurality elections as the measure of political competition, though in general the results are mixed. For example, Ansolabehere and Snyder (2006) do not find it to be significantly correlated with spending patterns across US states. An important paper by Besley, Persson and Sturm (2010) exploits the abolition of poll taxes and literacy tests in US states as a potential source of exogenous variation in political competition. Their results suggest that political competition is positively correlated with economic growth and negatively correlated with tax rates (a finding also presented by Besley and Case, 2003). The only other paper which, to our knowledge, develops a potential source of exogenous variation in political competition is Besley and Preston (2007), which uses re-districting as a source of variation, though focusing on policy convergence as the outcome variable.

[4]A companion article, available online, Reed and Robinson (2013), details the history of each of the 149 chieftaincies as best as possible using our survey data and available primary and secondary sources.

chieftaincy of the British colonial government in the late 1890s. Third, we show that all our results are robust to the inclusion of six detailed geographic controls that may be correlated with the economic development potential of a chieftaincy. Though two of these controls, distance to 1907 railroad and minimum distance to the country's three major towns, are themselves correlated with the log number of ruling families, the magnitudes of these correlations are small and unlikely to be economically significant. Finally, all specifications include individual-level ethnicity fixed effects, allaying concerns that they are driven by unobserved cultural variation across Sierra Leone's many ethnic groups.

Our first set of empirical results focus on educational, health and economic outcomes. We find a significant positive relationship between the number of ruling families and human capital outcomes, such as literacy and educational attainment, and also with the proportion of people working outside agriculture, which is a useful proxy for economic development (there are no nationally representative micro data on incomes in Sierra Leone). Quantitatively, the effects are substantial. Moving from the bottom quartile to the top (from 1.8 ruling families to 7.7) corresponds to an increase in literacy and primary and secondary school attainment of about 7 percentage points and in non-agricultural employment of 2.3 percentage points (in all cases from relatively low bases; for instance, 37% and 11% for literacy and non-agricultural employment respectively). We also find a substantial positive association between the number of ruling families and various measures of child health, asset wealth and housing quality.

Given that chiefs control access to land, which is not held as private property in rural Sierra Leone, an important mechanism is the relationship between the power of chiefs and the security of property rights in land. Using information from a nationally representative survey of agricultural households, we find that chiefs in chiefdoms with fewer ruling families have more authority to influence whether or not people can farm or sell a piece of land and that this authority is particularly strong if the people concerned were not born in the chiefdom.

An influential line of argument in political economy maintains that autocratic power of politicians and elites both results from and leads to low social capital and civic participation.[5] Interestingly, we find exactly the opposite in our data: places with fewer ruling families exhibit

[5]Putnam, Leonardi and Nanetti (1992), for example, develop this argument for the south of Italy. See also Bowles and Gintis (2002), Guiso, Sapienza and Zingales (2008), Tabellini (2010, Nannicini, Stella, Tabellini and Troiano (2013).

greater social capital on dimensions such as attendance of community meetings, participation in social groups and the undertaking of collective actions.

This somewhat puzzling finding, we suggest, arises because more dominant chiefs have been better able to mold civil society and institutions of civic participation in their villages for their own benefit and continued dominance—in a way that appears consistent with the case study literature on Sierra Leone (Fanthorpe 2001, 2005, Sawyer, 2008). As a consequence, relatively high measures of civic participation in villages with less constrained paramount chiefs are not a sign of a vibrant civil society disciplining politicians, but of a dysfunctional civil society captured by elites.[6]

This interpretation can also help explain another puzzling feature of the data: places with fewer ruling families have *more* favorable attitudes towards institutions of the paramount chief's authority.[7] If civil society has been captured, citizens will typically still find it valuable to interact with elites. But in places where paramount chiefs are less constrained, they are more dependent on chiefs' patronage and favors, and thus may find it useful to make specific investments in the system.[8]

We believe that our findings are relevant for understanding the consequences of the power of chiefs in Africa more broadly. As we discuss in our concluding remarks, the indirect rule institutions that established the chieftaincy in Sierra Leone had many similarities to those in other parts of colonial Africa. In this light, it should not be a surprise that our findings are consistent with several studies of the political economy of Africa and support the widely-held, but untested belief that the creation of unaccountable chiefs during the colonial period has had negative consequences for development (e.g., Ashton, 1947, Hill, 1963, and Crowder and Ikime, 1970, Migdal, 1988, Berry, 1993, and Mamdani, 1996). In Sierra Leone, predatory behavior by the

[6]As one paramount chief from Kono district told us in reply to a question about whether he was able to influence the way people voted in national elections: "if I say left they go left, if I say right they go right."

[7]In other parts of Africa, it is common for people to have positive attitudes towards chiefs' authority. Logan (2009, 2011), for instance, shows that traditional authorities enjoy considerable support from their people. In the AFRObarometer surveys she studies, 58% of respondents agree that "the amount of influence traditional leaders have in governing your local community should increase". Only 8% felt it should decrease. 61% of respondents report considerable trust in traditional leaders, whereas only 51% report such trust in local government officials. Results are similar for perceived corruption. Across Africa, traditional leaders are broadly viewed as more trustworthy and less corrupt than other institutions at the local level.

[8]This was observed for instance by Putnam et. al. (1993) in Southern Italy, where despite relatively low levels of measured social capital, citizens are more likely to visit the offices of local government officials; when they go, however, they are also more likely to ask for favors, such as employment.

chiefs is deemed to have been so severe that it is argued to have been a major cause of the civil war that erupted in 1991 (e.g., Richards, 1996).

Goldstein and Udry (2008) provide perhaps the sole empirical investigation of these issues and they show that connections to chiefs in Akwapim, Ghana are crucial in determining property rights to land and hence investment incentives in agriculture, though they themselves propose a relatively benign interpretation of the chiefs' actions.

Our results also complement a large literature critical of the purported positive correlation between social capital and development (e.g. Portes, 1998, Durlauf and Fafchamps, 2005; on Africa see Widner and Mundt, 1998, Jerven, 2010). Most related is the work of Anderson, Francois and Kotwal (2011) who find that in parts of western India where landownership is dominated by Maratha elites, development outcomes are worse, but measured social capital is higher. Their interpretation is similar to ours. Interestingly, it appears that just as in Sierra Leone, non-elites also have positive attitudes to the elite when the scope of the elite's power is greater. Our paper is also related to a small literature on economic consequences of indirect rule, including Lange (2009) and Iyer (2010).

The paper proceeds as follows. In Section 2, we briefly present the historical background of the chieftaincy in Sierra Leone, discussing how the institution was created, how it functioned and how it has persisted almost unaltered since the turn of the 20th century. This section also provides a detailed discussion of the origins of a sample of chieftaincies and their ruling families. Section 3 discusses the survey data we collected as well as the data on covariates and outcome variables, and presents some basic descriptive statistics. Section 4 examines the relationship between the number of ruling families and a measure of the concentration of their power. Section 5 shows that the number of ruling families is uncorrelated with various proxies for early economic development. Section 6 presents our main results on the impact of the number of ruling families on development outcomes, attitudes and measures of social capital. Section 7 concludes.

1.2 Historical Background

1.2.1 Chiefs and Indirect Rule in Africa

While chieftaincies in Africa have their roots in pre-colonial society, the institutions as they exist today were greatly shaped by colonial indirect rule. Indirect rule across Africa was viewed by colonial administrators as a way to maintain law and order, and to decrease the cost of local government administration by keeping in place the existing rulers and ruling through them. Though the policy of indirect rule was articulated most clearly as a tenet of colonial rule in British Africa, French colonial administrations also shaped rural institutions in similar ways (Guyer, 1978, Geschiere, 1993).

Indirect rule created few institutions through which political elites could be held accountable to their citizens. Lord Lugard, who elaborated the model during the pacification and control of Northern Nigeria, explained in his manual, *The Dual Mandate In British Tropical Africa* (Lugard, 1922, p. 203), how chiefs, despite their freedom to govern their people as they chose, would derive their legitimacy entirely from the colonial governmentab: "The chief himself must understand that he has no right to place and power unless he renders his proper services to the state." The chiefs, he wrote, "must work for the stipends and positions they enjoy." Chiefs were accountable to administrators, but not to their people. Lugard argued that accountability would be ensured if chiefs were selected according to "native custom". But the colonial interpretation and institutionalization of "native custom" typically made chiefs much less accountable than pre-colonial leaders had been, something certainly true in Sierra Leone (see Abraham, 2003, on Mendeland, Goody ed., 1979, more generally).

1.2.2 Chiefs in Sierra Leone

The colony of Sierra Leone was established in 1788, primarily as a settlement for freed slaves from the Americas and the Caribbean. The boundaries of the colony initially extended little beyond the environs of the main settlement and now capital, Freetown. In 1896 Governor Cardew unilaterally declared a Protectorate over the interior of the country, stating that signatories of previous treaties with the British colonial government, until then recognized as "native chiefs"with full political autonomy, were now subordinate to the government in Freetown.[9] The colonial government proceeded to establish a system of indirect rule, assessing a house, or "hut," tax in 1898. It imprisoned various chiefs who refused to pay (Chalmers, 1899). Though Cardew's declaration of a protectorate sparked the violent "Hut Tax Rebellion" led by Bai Bureh of Kasseh chiefdom and others, the government was largely successful in suppressing opposition. Over the next decade it established the chieftaincy, led by the paramount chief, as the administrative unit of indirect rule. The law of Sierra Leone now made the paramount chiefs responsible for the arbitration of land and legal disputes, the collection of tax revenue, and the general welfare of their people. The Protectorate Ordinance undermined many existing checks on the power of chiefs from within the chiefdom. For instance, Abraham (2003, p. 75) notes that previously, "in the case of a dispute between a king [chief] and his subject, the subject had the right to appeal to a neighboring king, which was not considered an indignity". Under the Protectorate, the local paramount chief became the highest authority in the civil legal disputes, and such appeals would have carried less weight.

After the declaration of the Protectorate, the colonial government established a formal system of succession in the chieftaincy in which paramount chiefs rule for life and are elected by vote of the 'Tribal Authority', a group comprising the members of the chiefdom elite. The authority also includes the 'chiefdom speaker', an aide to the chief. Chiefdom speakers will often temporarily take on the role of 'regent' or caretaker when a paramount chief dies. At the turn of the 20th century, these authorities were small groups of approximately 5 to 15 headmen and 'sub-chiefs' of the various towns and villages within the chiefdom. Their numbers have expanded over time. By the 1950s, voting rolls for elections of a paramount chief came to include approximately 40 to 60 members. The 2009 Chieftaincy Act provides that there must be one member of the Tribal Authority for every 20 taxpayers. Nevertheless, the Tribal Authority comprises mostly members of the rural elite. They are not elected by these taxpayers and neither is the paramount chief.

The declaration of the Protectorate also made the ruling family the unit of political competition within the chiefdom. Only members of ruling families are eligible to stand for election. The 2009 Chieftaincy Act stipulates that a person is qualified to stand as a candidate to be paramount chief

[9] See the Appendix in Goddard (1925) for a list of the treaties and signatories.

if he or she was born in wedlock to a member of a ruling family. “Where tradition so specifies”, this requirement is expanded slightly to include anyone with “direct paternal or maternal lineage to a member of a ruling family, whether born outside of wedlock or not”(Sierra Leone Legal Code, 2009, No. 10, Sec. 8.1.a-b.). A ruling family is recognized as one that was established before the time of independence in 1961.

Across chiefdoms there is broad consensus on the number of ruling families, though there is no official list even in the ministry in charge of the elections. Disputes over an individual’s membership in a family are resolved in cooperation with the Provincial Secretary, and often hinge on whether the aspirant can show his or her relative was recognized by British officials as being legitimate to stand for election before independence. Before the 2009 Act, elections were administered under a customary law that maintained the same basic principle: only members of established ruling families could stand.

Indirect rule created new opportunities for chiefs to seek rents and distort local economic activity. Perhaps the most egregious opportunity was provided by the land laws codified in the Provinces Land Act of 1927. These laws, still in place today, prohibit the transaction of land by ‘non-natives’—those not born in the chiefdom—and place ultimate ownership of all land in the hands of the paramount chief who, for this reason, is often called the ‘custodian of the land’. In chiefdoms with mining activity, chiefs are also eligible for direct payments of ‘surface rent’ from miners. These laws created opportunities for chiefs to capture rents from both private citizens and the central government. For instance, chiefs used their authority as custodian to impose elaborate tax structures on those who used the land for agriculture.[10] They also exploited this same authority to levy taxes on trade in and out of the chiefdoms. In addition, when public construction is undertaken for roads, schools, clinics and markets by the central government, the law requires that land lease agreements be negotiated with the chiefs, who often use these leases to extract payments for themselves.

Another rent-seeking opportunity was created by the chief’s role in providing local public goods from the tax revenue the government mandated them to collect. Lord Hailey examined

[10]For instance, we observed that today in Lokomassama chiefdom, the chiefdom authority levies specific tax rates on a variety of crops, and that non-natives of the chiefdom still complain about arbitrary taxes levied on their agricultural output.

Sierra Leone's local tax estimates for the year 1948, in which £134,302 (£3,810,000 in 2011, using a CPI deflator) were raised. Of this revenue, 58% was spent on administration; "the major part of this", he writes "representing payments to the Chiefs and office holders and members of the courts." Of the remaining expenditure, agriculture is only 3.5%, education 4.6%, forestry 1.9%, and public works 4.3%. Hailey writes, "an examination of the detailed estimates shows that many of the Native Administrations provide no service at all under some of these heads." Out of the 128 for which he had data, "only 51 made provision for expenditure on Agriculture, 56 for Education and 45 for Forestry." The public works, he wrote, were of terrible quality (Hailey, 1950, Part IV, pp. 307-308). Since the native administrations were also the primary conduit through which the central government administered public services, this also meant that in addition central government funds were available for capture.

Chiefs also preside over Sierra Leone's system of civil courts, which are responsible for the adjudication of land, ownership and matrimonial disputes. Maru (2006) cites numerous examples of chiefs intervening on behalf of family members in disputes over the payment of rent for agricultural land, suggesting that chiefs have in some cases badly perverted the administration of justice.

A final opportunity for the chiefs to exploit their power was created by the government's recognition of their authority to compel their subjects to undertake "communal labor". This authority was often used to pull scarce labor towards a chief's land during harvest season, potentially distorting labor markets. This phenomenon has deep historical roots; domestic slavery was commonplace in Sierra Leone until the early 20th century, a legacy of Sierra Leone's role as a major slave exporter. In 1923 it was estimated that 15% of the Protectorate population was in servitude, and the chiefs themselves were frequently large slave owners. Domestic slavery was outlawed in the Protectorate in 1928, but even then the law was only gradually enforced and in some places ignored (Arkley, 1965). Compulsory labor was a constant cause of dissent in the chiefdoms, but complaints by citizens were frequently ignored, both by the colonial administration and later by the post-independence government.[11]

[11] Records at the Forah Bay College National Archives show that in 1966 chiefdom councillors from a section of Yawbeko chiefdom in Bonthe district lodged a formal complaint with the government. They alleged that Paramount Chief Joe Jangba had both appropriated land unfairly from their section and compelled residents to labor without pay on various road projects in the area that would benefit the chief's farms. They wrote "it is no [sic] communal labour

1.2.3 Origins of Ruling Families

Our empirical strategy rests on the argument that the number of ruling families within a district was shaped by factors that are not direct determinants of development and social capital outcomes today. To support this argument we now provide case studies of six chiefdoms. In all cases, though there was some flux in the number of families in the late 19th century and at the turn of the 20th century, the number of families was fixed by around 1920, and did not change thereafter. The histories of all 149 chiefdoms and their families are discussed in Reed and Robinson (2013).

Koya chiefdom, of eastern Kenema district, is near the median of the distribution with three ruling families, all whom have contested the two most recent elections: Komai, Sellu and Kanneh. Local historians trace the origin of the chiefdom as a political unit to a warrior named Menima Kpengba, an ethnic Gola, who migrated from present day Liberia (see Kup, 1962, p. 127). The Komai and Sellu families both trace their lineages to the Gola people that migrated with Kpengba, and are affiliated with different towns in the chiefdom, Gbogbuabu and Bongor, respectively. The first paramount chief in Koya to be recognized by the colonial government was Joseh, of the Komai family, who signed a treaty at Gbogbuabu with Travelling Commissioner Thomas J. Alldridge on April 20th, 1890.[12] The Alldridge treaty was identical to many of the others signed throughout the 19th century. Under the treaty, Joseh promised the rights of free passage, property and construction to British subjects, and reserved adjudication of any disputes between his people and British subjects for the Governor in Freetown. "So long as the above conditions are carried out, and the roads are kept clean," the treaty reads, "Chief Joseh shall receive an annual present of ten pounds."

Joseh joined the rebellion in 1898 against the declaration of the Protectorate, and in retaliation, Captain Carr burned Gbogbuabu to the ground. Joseh was deposed and imprisoned for a year. He returned to office in 1899, at the age of "35 to 40", and was ultimately succeeded by his younger

when force has been put to bear on us. We have been tortured, molested, illegally fined and sent to the Chiefdom lock-up in case of resistance to work the road." What is striking is the response of the Provincial administration, then independent of Britain. In a subsequent letter, the District officer of Bonthe wrote to the Provincial Secretary in Bo that the matter had been summarily closed:"I confirm that I have severely warned the petitioners—and everyone present at that—to avoid the slightest repetition of such questionable conduct," a reference to their complaint. The petitioners were compelled subsequently to sign an apology letter, begging obsequiously for forgiveness.

[12] Fourah Bay College Archives, Treaty, April 20, 1890: Borgbahboo.

brother Kormeh, by unanimous vote of 32 tribal authorities in 1907.[13] That Joseh, as with most chiefs imprisoned after the rebellion, was able to return to power and pass the chieftaincy to his brother shows the resilience of the ruling families' lineages.

After Kormeh's death in 1920, Sellu Ngombu, of the Sellu family, held the chieftaincy as "caretaker" or regent. A 1920 letter to Freetown from the District Commissioner states that after Kormeh's death a regent chief was elected immediately.[14] A third ruling family, Kanneh, has dominated the chiefdom since Kormeh. It is likely that Kanneh was related to a section chief who had ruled an area of the chiefdom under Kormeh and Sellu.

This example illustrates a common feature across chiefdoms, which is that a family may have obtained the right to stand for paramount chief through service as regent chief early in the history of the chiefdom. The existence of such families depends on whether an original paramount chief had a clear successor; in this case Kormeh had no son.

It is common across chiefdoms for the absence of a clear heir to the chiefdom's forbearer early on to lead to the legitimation of new families. Take, for instance, Bagbo chiefdom in Bo District. Bagbo traces its origins to Boima Jah, a warrior and hunter who settled the area, and was chief from 1847 until his death in 1884.[15] The chiefdom today recognizes four families: Jah, Idriss, Coker and Colia. The Colia family, which is descended from a family living in the chiefdom at the time of Boima Jah, has contested but never won a chieftaincy election. The Idriss and Coker families emerged because Boima Jah did not have any sons, and after his death there was no immediate successor. Idriss, the chiefdom speaker, succeeded Jah as regent chief. Similar to Sellu Ngombu, though Idriss had no blood relationship to Jah, his family has come to be considered a ruling family. After Idriss's death in 1897, Keneh Coker was elected chief. His mother was a daughter of Boima Jah who had married into the Coker family. Keneh Coker had a long rule until 1942, and, at least in 1912, received a stipend from the government of ten pounds a year.[16]

[13]Provincial Secretary's Office, Kenema: Kenema District Decree Book.

[14]Provincial Secretary's Office, Kenema: Kenema District Decree Book.

[15]Local historians memorialize his military prowess in their interpretation of the word Bagbo, which they take to mean in Mende: "don't be stupid while sleeping"; one must be vigilant, even while resting, of the potential for enemy attack.

[16]Fourah Bay College Archives, "Information Regarding Protectorate Chiefs 1912".

Some new ruling families were also created through marriage. This occurrence was particularly common when the first chief had no sons old enough to become chief. In these cases, new families are created when his daughters were married into other families, and their husbands stood for election. Though these families eventually became prominent, it often took some time early on for these new families to be viewed as legitimate. As with the Sellus, files from the District Commissioner in 1906 list Coker as "regent", not paramount chief, indicating that even nine years after Idriss's death, he was still viewed as a place holder for the family of Boima Jah.[17] This did not last forever, however; as his family held the chieftaincy twice after Keneh Coker's death.

There are of course situations in which the forbearer of a chiefdom had an abundance of heirs, who continue to dominate the chiefdom until the present day. Simbaru chiefdom, which like Koya is also in Kenema district, is just one of these chiefdoms. Though in the same region, with a similar ethnic makeup, it only recognizes one ruling family. Oral historians trace its origin back to a warrior and hunter named Gombulo Tama, who settled the area with his brother Jaiwu. Tama made his settlement at Javoima while Jaiwa settled at Goma. Abraham (2003, p. 113) traces the origin of Simbaru to the expansion of Keni Karteh, a warrior of the early 19th century who, with his warriors, expanded to occupy areas surrounding his town of Dodo. Tama and his brother were probably warriors under the command of Karteh. The first chief from this house to be recognized by the British, Sangwewa, was a grandson of Gombulo Tama. His family has dominated the chiefdom as its sole ruling family ever since, as there has always been a male heir to take the chieftaincy.

The organizational structure of groups of invaders during the pre-colonial period also have affected the number of families. Sierra Leone's pre-colonial history was one of great turmoil, and the leadership of the areas that would later become chiefdoms changed frequently. Take, for instance, Mambolo chiefdom in northwestern Kambia district, which has five ruling families. Oral history speaks of a woman named Borkia who migrated from present day Guinea. She is likely to have come as part of the Mane invasions of the mid-16th century. Some time thereafter, her settlement was conquered by a group of Bullom warriors, to whom each one of the chiefdom's five families traces their lineage.

[17] Fourah Bay College Archives, Railway District Decree Book 1900-1904.

It is just as common for families to have successfully fought off invading tribes. Kassunko, in northern Koinadugu district, has five recognized ruling families. The chiefdom traces its roots to Limba warriors who conquered the Lokos in the area during the 15th century (Kup, 1962, p. 124). The Limba later faced their own invasion by the Sofa, from present day Guinea, in the 1880s. Lipschutz (1973) records an interview with Paramount Chief Baio Serry II of Kassunko in 1972 in which Serry recalls how his grandfather made peace with the Sofa and maintained the independence of the chiefdom. The story is that his grandfather Sara Baio's fingers were gnarled. The invaders said that whenever they met a person with such a deformity, they should not touch him, and so they did not fight. A government report from 1912 recalls that Sara Baio, then an old man, "has the confidence of his people".[18]

While the set of families with legitimacy to rule the chiefdoms was certainly variable in the pre-colonial period, ruling families have stayed incredibly resilient to change since the beginning of the 20th century. This can be seen in Mandu, of Kailahun district. There President Siaka Stevens installed a loyalist of the then ruling All People's Congress Party (APC) as chief in 1983 in order to gain political control over the area. There was only one ruling family in this chiefdom, the Coombers, and the installed chief was not a member. The Coombers trace their lineage to Kaba Sei, an important chief at the turn of the 20th century and son of the original settler, Mandu Falley. The family appears to have consolidated its legitimacy in the area at the end of the 19th century, after Kaba Sei fought against an invasion by Ndawa, a great warrior of the time (Abraham, 2003, p. 85). Stevens appointed a chief, J.B. Bunduka, who reigned until 1991 when he was the first paramount chief to be murdered by the Revolutionary United Front, the first rebel group of Sierra Leone's civil war, which had sworn to free the country from APC oppression (Smith et. al., 2004). Today, relatives of Bunduka are not recognized as a ruling family.[19]

From this historical material, we conclude that there are many idiosyncratic sources of variation in the number of ruling families across chiefdoms that are unlikely to be correlated with factors that determine development and social capital outcomes today.

[18]Fourah Bay College Archives, "Information Regarding Protectorate Chiefs 1912"

[19]A total of seven chiefdoms had new families installed by politicians after independence: Biriwa, Neya, Kaffu Bullom, Koya (Port Loko), Kalansogoia, Neini, Mandu. Since the civil war, none of these families have been viewed as legitimate or permitted to stand in elections. We drop these families from the analysis below. Appendix Table A.12 shows that our core results are robust to the inclusion of these families.

1.2.4 Ruling Families as Political Competitors

Indirect rule formalized the ruling family as the unit of political competition in Sierra Leone's chiefdoms. In his study of the Mende chiefdoms of Kenema District, Burrows (1976, p. 202-203) makes an analogy between the ruling families and political parties:

> "Ruling house rivalries provide the major source of conflict in Mende chiefdoms. In most cases [...] this cleavage fashions the broad outlines of political competition. Structurally, the semblance of a two- or multiparty system is built into chiefdom politics because (almost) every chiefdom has at least two ruling families. In fact, local people often use the terms 'ruling party' and 'opposition party'."

Burrows goes on to suggest that the intensity of competition is increasing in the number of families:

> "Of the sixteen chiefdoms in Kenema district [...] Simbaru is the only chiefdom [...] boasting only one ruling family; as might be expected, its politics are characterized by widespread consensus and little overt conflict. In Dodo and Nomo [each with 2 families], family rivalries are muted. At the other end of the spectrum, Nongwa [4 families], Gaura [5 families], Tunkia [3 families] and Lower Bambara [2 families] are examples of intense ruling house conflict; all other aspects of local political interaction are remaindered subordinate to the demands of this basic cleavage in these chiefdoms."

In many cases, these rivalries between families are a tacit competition for the rents of office. A salient example of this is Murphy's (1990, p. 30) description of a number of chiefdoms with active diamond prospecting:

> "Despite election rhetoric of bringing 'development,' chieftaincy contests between ruling houses [...] centered on the more covert issue of which house would monopolize the diamond resources for its members and supporters. These benefits include privileged access to the most productive diamond areas, and fees and gifts from outside diamond diggers as well as any foreign concessions operating in the chiefdom."

When chiefs and their families have abused the office, however, other families are often able to build a stronger case that the family in power be deposed in a subsequent election. We witnessed this ourselves during our fieldwork in 2009. That year, in Lower Banta, the Margai family was thrown out of power and replaced by the Nyama family because of discontent with the previous chieftaincy of George Margai, and the view that he had unfairly privileged members of his family in legal disputes. Similarly, in Sogbini chiefdom, during the election for a new paramount chief in December of the same year, the Bio family, which had ruled the chiefdom since the signing of the first treaty with the British, was displaced by the Bayo family, the only other ruling family. Local informants told us that the reason for the switch in support was that the previous paramount chief Charlie Bio II had seriously neglected his duties, spending more time on drink than on the administration of the chiefdom. In these cases, it was easier for opposition families to garner votes, given the public recognition of misrule by the family in power.

1.3 Data

1.3.1 Documenting Chieftaincy Institutions

To measure the power of the various paramount chiefs we have created, to our knowledge, the first comprehensive list of ruling families across chiefdoms, and the first comprehensive history of the chieftaincy in Sierra Leone.

Though detailed records of some chieftaincy elections exist, many were destroyed during the civil war when the Provincial Secretaries' offices in Bo and Makeni were razed, making the written record insufficient to construct such a dataset. To complement archival records and secondary sources, we conducted a survey of all 149 chiefdoms.[20] To do this, local researchers with local language skills were trained in qualitative interview methods and visited all 149 chiefdoms. Through extensive interviews with local oral historians, known as "encyclopedias", researchers constructed the lists of ruling families and lists of previous chiefs as far back as respondents could recall, and recorded origin stories of each of the ruling families. Researchers were required to visit members of each ruling family in order to ensure that they obtained a balanced perspective on the family's history and the history of the chiefdom.

While there is strong consensus within chiefdoms about the number of ruling families, the subjective nature of the interview process raises some concern about measurement error, particu-

[20]Of the secondary sources, Fyfe (1960), which gives a comprehensive history of 19th-century Sierra Leone and information on native rulers, is the most important. See also Alie (1990). Other sources cover different regions in the country. Abraham (1979, 2003) is authoritative on Mendeland in the south of the country (see also Little, 1951). Wylie (1977) covers Temne country in the north, Finnegan (1965) and Finnegan and Murray (1970) the Limba country (see also Fyle, 1979a,b, and Fanthorpe 1998). Howard (1972, 1976) studies the 19th-century Guinea border country in the northwest, and Lipschutz's (1973) study focuses on the northeast.

larly if researchers systematically recorded more families in chiefdoms with better development outcomes. Given their training, and the corroboration of their reports with those in secondary sources, we believe this is highly unlikely. Moreover, although we cannot provide a formal test for a systematic and equal bias on the part of all researchers, we can test for bias at the level of the individual researcher. Researchers operated in teams of two, alternating partners, allowing us to include researcher specific fixed effects as a robustness check. In Appendix Table A.12, we present some of our core results with researcher fixed effects included. Adding these fixed effects will change our estimates if our results are driven by a strong bias on the part of some researchers. In practice, the coefficient estimates do not change in magnitude or significance.

There is variation across chiefdoms about how far back the oral historians could recall. Some chiefdoms are able to trace their histories back until the 18th century, while others can only remember back to the 1930s. In addition, for amalgamation chiefdoms, which were created in the late 1940s and 1950s by the colonial administration by amalgamating smaller chiefdoms for tax collection purposes, researchers were unable to trace lineages of all the component chiefdoms. Hence our record for these chiefdoms only goes back until the period of amalgamation. This means that recall is lower in amalgamation chiefdoms on average. Though it does not directly affect our key variable, the number of ruling families, we wish to control for recall, and we thus add to all specifications the number of paramount chiefs the historians could recall. We also control for whether the chiefdom is created by amalgamation. In our core results, we report the estimates for these controls; in most specifications they are insignificant at standard levels.

Appendix Table A.1 gives a list of all of the chieftaincies ordered by district with information on the number of ruling families, whether or not the chieftaincy was the result of an amalgamation between previously separate chieftaincies, and also the number of paramount chiefs that the oral historians could remember. Table 1.1 gives some basic descriptive statistics by quartiles of the number of ruling families. Panel A shows that the average number of ruling families is 4.0, ranging from 1 to a maximum of 12. The mean number of chiefs recalled by oral historians was 5.8. This was slightly larger for chieftaincies in the lowest quartile of the distribution of the number of families. This panel also shows that 30% of the chieftaincies were formed by amalgamation.

Table 1.1: *Descriptive statistics*

		Number of observations	By quartiles of number of ruling families (1)	(2)	(3)	(4)
A. Chieftaincy variables and controls						
Number of ruling families	4.0 (2.1)	149	1.8	3.5	5.0	7.7
Herfindahl office holding concentration index	0.54 (0.24)	149	0.72	0.52	0.40	0.42
Maximum seats for family with most seats	3.5 (1.7)	149	4.6	3.1	3.0	2.6
Number of chiefs recalled	5.8 (2.6)	149	6.3	5.7	5.8	5.2
Amalgamation	0.3	149	0.02	0.30	0.45	0.72
B. Development outcomes, by data source						
Census						
Literacy rate	0.32	2,727,622	0.31	0.31	0.32	0.33
Primary school attainment	0.35	2,717,412	0.37	0.35	0.35	0.36
Secondary school attainment	0.16	2,193,151	0.16	0.16	0.16	0.17
Non-agricultural employment	0.13	2,919,953	0.11	0.13	0.13	0.16
Demographic Health Survey (DHS)						
Weight for height Z-score (under 5)	-0.15 (1.60)	1,521	-0.14	-0.14	0.05	-0.27
Anemia (under 5)	0.50	1,423	0.52	0.50	0.54	0.47
Household wealth index $\in [0,5]$	2.4 (1.2)	4,994	2.39	2.33	2.49	2.62
National Public Services Survey (NPS)						
Asset wealth index	0.139	5,143	0.126	0.146	0.132	0.155
Housing quality index	0.360	5,167	0.303	0.367	0.335	0.447
C. Property Rights, by rice plot (*ATS*)						
Has asked chief to use land?	0.12	8,450	0.16	0.13	0.10	0.09
Has right to sell land?	0.42	8,393	0.48	0.43	0.47	0.31
D. Attitudes (*NPS*)						
Agrees one should respect authority	0.44	5,167	0.46	0.44	0.40	0.42
Agrees only older people can lead	0.30	5,167	0.30	0.28	0.33	0.27

Table 1.1: *Descriptive statistics (continued)*

			By quartiles of number of ruling families			
		Number of observations	(1)	(2)	(3)	(4)
E. Social Capital (*NPS*)						
Bridging capital index	0.33	4,582	0.37	0.33	0.35	0.29
Attended community meeting in last year	0.38	5,124	0.42	0.37	0.39	0.34
Bonding capital index	0.20	4,139	0.24	0.20	0.19	0.17
Credit/savings group member	0.16	5,146	0.17	0.18	0.17	0.11
Labor gang member	0.21	5,150	0.24	0.20	0.25	0.17
Secret society member	0.33	5,140	0.40	0.32	0.27	0.32
Collective action index	0.26	5,065	0.31	0.26	0.26	0.18
Participated in road brushing in last month	0.36	5,139	0.43	0.37	0.36	0.28
F. Historical and geographic correlates of economic development						
Hut tax assessment (£per 100 km^2)	85.3	87	94.5	88.9	54.1	86.9
	(117.6)					
Hut tax assessment (£per 1000 people in 1963)	27.6	86	39.6	24.0	14.8	28.4
	(0.019)					
Distance to 1895 trade routes (km)	20	149	27	18	16	14
	(19)					
Distance to coast (km)	105	149	120	105	92	91
	(66)					
Distance to river (km)	9	149	12	8	8	9
	(7)					
Distance to 1907 railroad (km)	45	149	44	46	45	38
	(30)					
Minimum distance to Bo, Freetown or Kenema (km)	79	149	81	79	79	78
	(44)					
Mining permissions in 1930s	0.17	149	0.15	0.21	0.23	0.08

Notes: Standard deviations presented in parenthesis; no standard deviation reported for binary variables. All individual outcomes are matched on chiefdom of birth except for outcomes from the ATS and DHS surveys, which are matched on chiefdom of residence.

The upper left hand panel of Figure 1.1 shows visually how the numbers of families are distributed geographically in Sierra Leone. We plot here the quintiles of the number of families with the darkest color corresponding to those chieftaincies in the top quintile of the distribution (the 30 chieftaincies with the highest number of families). This figure makes it clear that chieftaincies with many families are not clustered into any particular area of the country. Some are close to Freetown in the west of the country. Others are right down in the south-west on the coast, or further north on the border with Guinea. Others are in the far northeast, and still others are clustered in the center of the country. The map also contains prominent 1895 trade routes (Mitchell, 1962), paths of navigable rivers, and the 1907 lines of rail. The chieftaincies with the highest number of families do not seem to cluster around navigable rivers, trade routes or the railway lines. In Section 4, we will investigate these relationships more systematically.

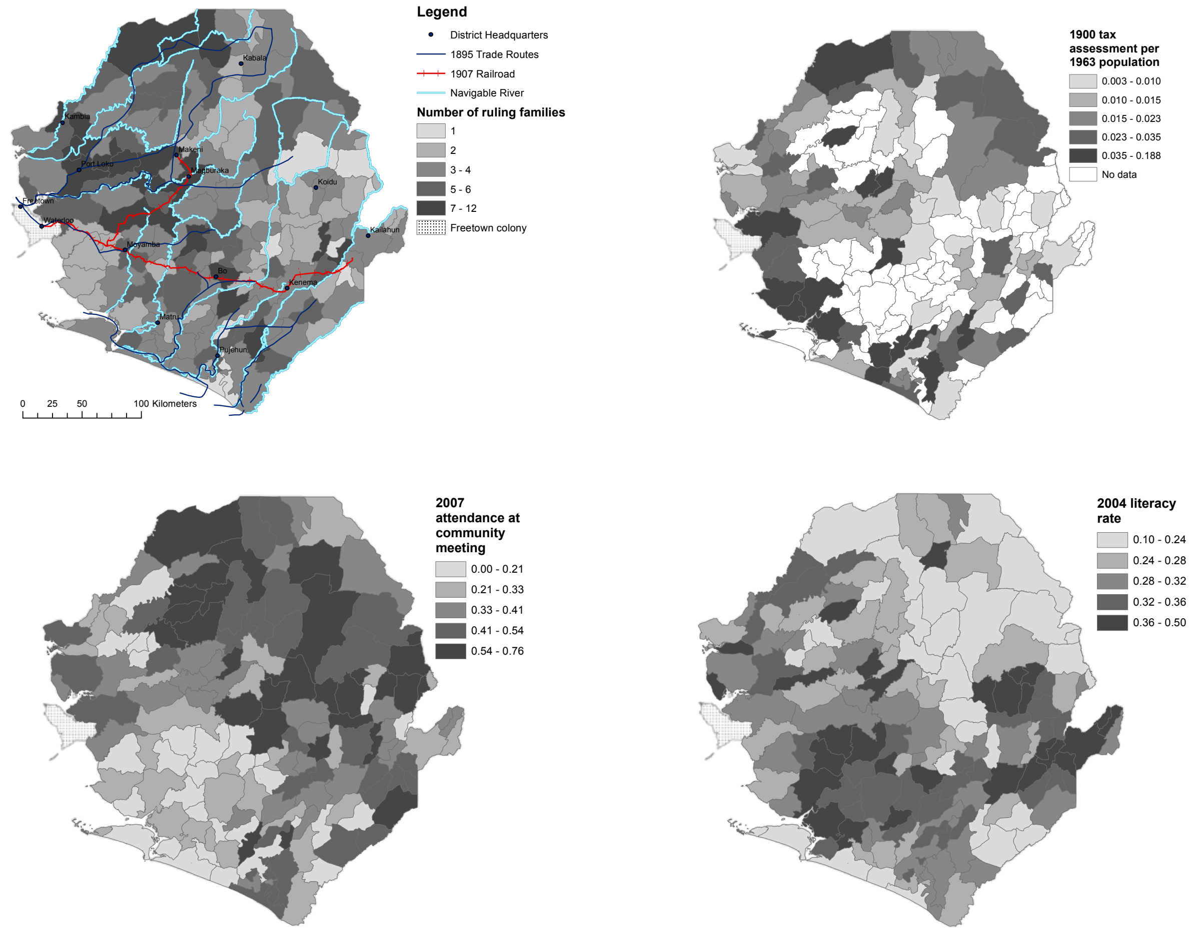

Figure 1.1: *Map of Sierra Leone's chiefdoms*

Notes: Map is oriented north, with 4 variables plotted by quintiles. The variables are, clockwise from northwest, the number of ruling families, the 1900 average annual tax assessment per 1963 population (in nominal pounds sterling), 2004 literacy rate, and share of respondents in the NPS who have attended a community meeting in the last month. Literacy and community meeting attendance are matched on chiefdom of birth.

1.3.2 Outcomes

We study the effect of the number of ruling families on a wide range of development and social outcomes. Our primary data sources are the 2004 Sierra Leone Census, the 2008 Demographic and Health Survey (DHS) the 2007 National Public Services Survey (NPS), and the 2010 Agricultural Household Tracking Survey (ATS). We use the census to study educational and employment outcomes and the DHS to study health outcomes of children under five. We use the NPS to study attitudinal and social capital outcomes, as well as housing quality and asset ownership, and the ATS to study property rights of land holders. Finally, we also use the 1963 census for a cohort analysis of human capital to investigate when the gap between chiefdoms with high and low development outcomes began to occur.

Panel B of Table 1.1 shows the descriptive statistics of key development outcomes by dataset. Unless otherwise specified, we match individuals to chiefdoms based on chiefdom of birth, which provides a better sampling frame for the investigation of the link between chieftaincy institutions and long-run development.[21] The literacy rate among those born in Sierra Leone's chiefdoms is very low, 32%. It is somewhat lower, 31%, for chiefdoms in the lower quartile of the number of families, and somewhat higher, 33%, for chiefdoms in the highest quartile of the number of families. The lower right hand panel of Figure 1.1 plots quintiles of literacy on a map.

The NPS, which is a survey of household heads, contains additional development outcomes. From the survey data we create an index of asset wealth, which is simply the unweighted mean of eight dummies for ownerships of particular assets, such as a mobile phone or a radio, and of housing quality, which is the unweighted mean of indicators for whether the household has a cement or tile floor, a cement or zinc wall, and a zinc roof (all relative to dirt or thatch).[22] Each index ranges from zero to one. These indices were created using all survey questions available

[21] As shown in Appendix Table A.9, the results are similar when we match individuals based on chiefdom of current residence.

The statistics in Table 1.1 are not fully representative of Sierra Leone nationally as they only include the 84% of the population born in chiefdoms; excluded are those born in either Freetown and the Western Peninsula surrounding it, or in any of the five urban town council administrations of Bo, Bonthe, Kenema, Koidu, Makeni.

[22] Namely, the asset wealth index is an unweighted average of dummies for the ownership of a bicycle, generator, mobile phone, a car, truck or motorcycle, fan, radio, umbrella, and television. The housing quality index is an unweighted average of three dummies indicating ownership of a cement or tile floor, a cement or tile wall, and a zinc or tile roof.

to guard against selection of variables with significant relationships; in Appendix Table A.5 we present results for each of the individual measures of asset wealth and housing quality separately.

The ATS survey provides us with information on property rights for plots of rice, the national staple.[23] This nationally representative survey covers 142 of 149 chiefdoms, and asks households, for each plot, whether they have the right to sell the land and whether they have to ask permission to farm the land from a chief or traditional authority. We code two indicators for these outcomes. Summary statistics for the sample are presented in Panel C of Table 1.1.

We use the DHS to study health outcomes for children under five. The DHS sample, which is smaller, covers only 117 of 149 chiefdoms, but these chiefdoms still span the full range of the numbers of families, from 1 to 12, with quartile averages of the number of families being very close to those in the full sample, at 2.3, 4, 5, and 7.5. In this dataset, children are matched to chiefdoms based on chiefdom of current residence, as chiefdom of birth is unavailable. The health outcomes reported in Panel B of Table 1.1 show the poor state of childhood health in rural Sierra Leone. The DHS also includes a wealth index constructed by DHS researchers using a principal components analysis.

Finally, Panels D and E of Table 1.1 present the data on the attitudinal and social capital variables from the NPS, which we discuss below.

1.3.3 Historical and Geographic Correlates of Development

To investigate whether the number of ruling families is systematically related to prior development outcomes or factors that might help to determine economic development, we also study the relationship between the number of ruling families and proxies for economic development in 1900. As proxies for prior development we use average annual hut tax revenue assessed by the colonial government between 1898 and 1902. The official tax rate at the time was 10 shillings (£0.50) per house with greater than four rooms and 5 shillings (£0.25) for every house with three or less rooms (Chalmers, 1899). These tax assessments provide a useful proxy for the wealth of a chiefdom at the turn of the 20th century.

The source for the tax assessments is *Tax Book for Various Chiefdoms and Districts 1898-1902*,

[23] We thank Tavneet Suri for sharing these data and for assistance in using it.

which contains a comprehensive list of the tax assessments on all recognized chiefdoms at the time and which we accessed in June 2010 in the National Archives at Fourah Bay College in Freetown. Though many chiefdoms have maintained their boundaries since 1898, some have not and the mapping to chiefdoms today is imperfect. Historical chiefdoms were manually matched to current ones using the names of the chiefdom. This work was aided by historical records which we utilized to identify name changes.[24] Annual averages were then constructed for each chiefdom, using the simple mean of total chiefdom tax assessment for all years observed between 1898 and 1902.[25] Across years, an average £33,254 was assessed annually. In total 91% of this average tax assessment was mapped successfully to a chiefdom, leaving £3,172 unmapped. A total of 87 contemporary chiefdoms were linked to a tax assessment. Reliable population estimates by chiefdom are not available for this time period, so we normalize tax assessment alternatively by square kilometer and 1963 population in our specifications.[26] Tax assessments are plotted in the upper right hand panel of Figure 1.1. The data cover most of the country, though there are also missing data for several chiefdoms (particularly those in the regions of north and south where unrest following the 1898 hut tax rebellion was most pronounced).[27]

In addition to the tax data we use distance from the chiefdom centroid to the coast, nearest navigable river, the 1907 railroad, and minimum distance to Sierra Leone's three major towns as proxies for development in 1900. We also use distance to 1895 trade routes reported by Mitchell (1962), who mapped them based on the 1895 report of Governor Rowe after a trip around the country to explore its economic potential. Centroid distances to these variables were calculated

[24]In three cases, an assessment was recorded for a chiefdom that is today split into two chiefdoms. In these cases, the assessment was split between today's chiefdoms using their relative surface areas as weights.

[25]Taxes were not assessed in some areas during some years, particularly in 1899 in the immediate aftermath of the hut tax rebellion.

[26]One chiefdom, Dibia, is missing data in the 1963 census, reducing the number of observations in this normalization to 86.

[27]One can provide a very rough estimate of whether the total tax assessment observed in these data is reasonable given the population at the time. According to the 1921 Native Census, the native population of the Protectorate in 1921 was 1,450,903, an increase from 1,323,151 in 1911. This implies a 9.6% growth rate over the decade. In 1921, there were 239,148 households, with an average of 5.9 people per house. If we assume a constant growth rate in the previous decade, this implies that in 1901 there was a population of 1,207,254, or using the 5.9 people per house, 204,619 houses. If everyone had a house of three rooms or less, with £33,254 assessed each year, this means that about 65% of the houses were assessed. This number stacks up closely with the 58% of chiefdoms we could match to an assessment. Assuming an uniform distribution of houses across chiefdoms, this implies an almost complete assessment of the chiefdoms covered.

using GIS maps of the chiefdoms provided by Statistics Sierra Leone. Finally, we also construct a dummy for the presence of mining permits in the 1930s, during the beginning of the country's mining boom. These permits were accessed and documented in June 2010 at the National Archives at Forah Bay College. Panel F reports information on these variables.

1.4 The Number of Families and the Concentration of Power

Our argument rests on the claim that in chiefdoms with more ruling families there will be greater political competition and fewer opportunities for the concentration (and abuse) of power—and on the basis of this, we use the terms "greater political competition" and "less concentrated political power" interchangeably.

Our first exercise is a simple reality check to show an empirical link between the number of families and some simple measures of the concentration of power within a chiefdom — though we cannot measure the concentration of *de facto* power, which is most relevant for our argument.

To measure the concentration of power we construct a Herfindahl index of the extent to which the office of paramount chief has been dominated by a subset of ruling families over time (Stigler, 1972).[28] In each chiefdom c we observe F^c, the set of ruling families, and S^c the set of chieftaincy seats, as far back as the oral historians could remember. We exclude seats held by regent chiefs, unless they initiated a ruling family, and seats held by those few chiefs who were viewed as illegitimate for other reasons. Let $N^c = |S^c|$, the number of seats observed. Let s_f^c be the number of seats held by family f. The Herfindahl index is then computed as

$$H_c = \sum_{f \in F^c} \left(\frac{s_f^c}{N^c} \right)^2 .$$

As shown in Panel A of Table 1.1, the average Herfindahl across chiefdoms is 0.54 and tends to be much higher in chiefdoms with fewer families.

To describe the link between the number of families and the concentration of power we run

[28] See Acemoglu, Bautista, Querubín and Robinson (2008) for a similar index to measure the extent to which a small number of people controlled local political power in Colombia. In Appendix Table A.2 we show similar results using an alternative measure of the concentration of power: the maximum number of seats held by a family.

OLS regressions of the following form,

$$H_c = \delta_d + \alpha_{fam} \cdot F_c + \gamma_c \cdot N_c + \gamma_a \cdot \text{Amalgamation}_c + \varepsilon_c. \tag{1.1}$$

We abuse notation slightly and let F_c stand for either the number of ruling families in chiefdom c or its logarithm depending on the specification. The δ_d's denote a full set of 12 district fixed effects; N_c is the number of chiefs in the history of the chieftaincy that the oral historians could remember in c; and Amalgamation_c is a dummy variable which is equal to 1 if the chieftaincy was amalgamated, and equal to 0 otherwise. Finally ε_c is the error term.

Table 1.2 shows estimates of equation (1.1), documenting the relationship between the number of ruling families and power concentration. Columns 1-2 present the most parsimonious version of (1.1), without including any controls. In column 1, the estimated coefficient on the number of ruling families is $\alpha_{fam} = -0.05$ with a standard error of 0.01 and is significant at less than 1%. The R^2 is relatively high, at 0.20, suggesting that variation in the number of families accounts for 20% of the variation in our measure of concentration of power. Column 2 presents a similar model with the natural log of the number of ruling families. The results are similar, but more precisely estimated and with a higher R^2 ($= 0.33$). The F-statistics also indicate that the fit is considerably better with the log specification. The patterns and estimated coefficient vary little in column 3 which includes the amalgamation dummy, the number of chiefs recalled and district fixed effects, and in column 4, which includes six geographic characteristics potentially correlated with economic development, which will be discussed in the next section.

The better fit of the log specification is confirmed again in columns 5, which include both the number of ruling families and its log. The log variable continues to be negative and significant, while the number of families becomes positive, indicating that, if anything, a transform more concave than the logarithm would be an even better fit to the data. This likely reflects the fact that much of the gains from greater political competition occur when the number of ruling families increases starting from a low base. These patterns motivate our focus on the log specification in subsequent regressions. Figure 1.2 presents the fit estimated in column 3 graphically.

Table 1.2: *The number of ruling families and the concentration of power over time.*

	(1)	(2)	(3)	(4)	(5)
Dependent variable	Herfindahl office holding concentration index				
# of ruling families	-0.05				0.07
	(0.01)				(0.01)
ln(# of ruling families)		-0.25	-0.31	-0.30	-0.56
		(0.03)	(0.03)	(0.03)	(0.05)
Amalgamation			0.12	0.09	0.06
			(0.06)	(0.06)	(0.06)
Number of chiefs recalled			-0.02	-0.02	-0.02
			(0.01)	(0.01)	(0.01)
F	28.12	81.24			
R^2	0.20	0.33	0.47	0.49	0.53
Observations	149	149	149	149	149
District fixed effects	NO	NO	YES	YES	YES
Geographic controls	NO	NO	NO	YES	YES

Notes: Robust standard errors in parentheses. The Herfindahl index has mean 0.54 (s.d. = 0.24). Geographic controls are a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown.

1.5 Number of Ruling Families and Pre-Colonial Development

As we discussed in the Introduction, a major challenge for the interpretation of the results we present is the possibility that the number of ruling families might be determined by the extent of pre-colonial prosperity. Even though the historical sources and our survey and fieldwork suggest that the causes of differing numbers of families were largely idiosyncratic, we now investigate this possibility more systematically. Table 1.3 presents regressions of the form

$$y_c = \delta_d + \alpha_{fam} \cdot F_c + \gamma_n \cdot N_c + \gamma_a \cdot \text{Amalgamation}_c + \varepsilon_c, \tag{1.2}$$

where y_c is the dependent variable of interest. Specifications include our baseline controls for amalgamation and the number of ruling families and district fixed effects δ_d; ε_c is again the error term. Our objective is to examine whether the (log) number of ruling families is meaningfully correlated with measures of pre-colonial economic development or potential determinants of subsequent development.

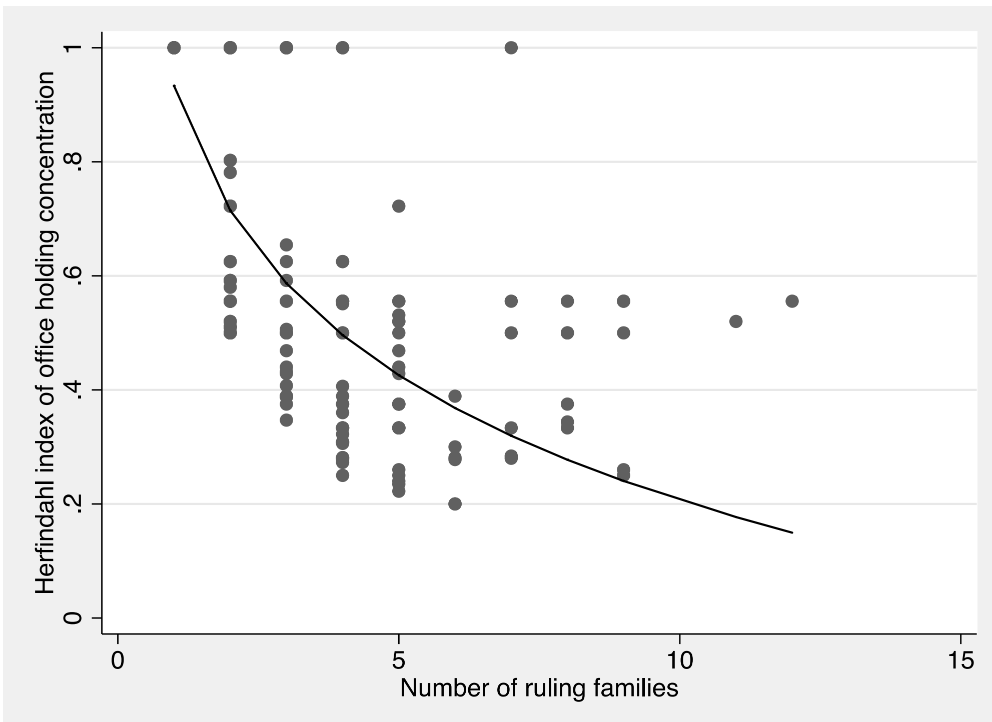

Figure 1.2: *Number of ruling families and the Herfindahl index of the concentration of power.*

Notes: The fitted curve corresponds to the model in column 3 of Table 1.2, which includes the log number of ruling families and controls for district effects, the number of seats observed, and an amalgamation dummy.

Table 1.3: *Number of ruling families and correlates of early development*

Dependent variable	(1) 1900 tax per 100 km^2	(2) 1900 tax per 1000 1963 pop.	(3) 1900 tax per 1000 1963 pop.	(4) 1930s mining permits	(5) Dist. to coast	(6) Dist. to river	(7) Dist. to 1895 trade routes	(8) Dist. to 1907 railroad	(9) Min. dist. to major towns	(10) Predicted literacy
Ln(# of ruling families)	-26.07	-2.94	-3.19	0.01	-2.73	-0.98	-2.35	-6.78	-10.80	0.010
	(29.64)	(6.07)	(6.13)	(0.06)	(5.07)	(1.19)	(2.81)	(3.27)	(3.84)	(0.006)
Amalgamation	62.42	0.86	1.01	-0.04	8.33	1.22	4.04	6.88	8.46	-0.011
	(78.00)	(9.95)	(10.28)	(0.10)	(6.74)	(2.04)	(3.23)	(4.70)	(5.67)	(0.007)
Number of chiefs	12.38	-0.60	-0.38	0.01	0.73	0.82	0.83	-0.30	0.17	-0.000
recalled	(10.99)	(1.47)	(1.44)	(0.01)	(1.21)	(0.35)	(0.50)	(0.76)	(0.88)	(0.001)
Thousands of			-0.71							
strangers			(0.58)							
R^2	0.32	0.41	0.41	0.22	0.86	0.18	0.57	0.72	0.80	0.74
District fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	87	86	86	149	149	149	149	149	149	149
Outcome mean	85.31	27.56	27.56	0.17	105.33	9.18	20.19	44.19	79.21	0.307
Outcome s.d.	117.57	29.28	29.28	0.38	65.61	7.22	19.94	30.34	44.27	0.044

Notes: Robust standard errors in parentheses. All distances are in kilometers and are calculated with reference to chiefdom centroids. 1900 taxes in columns 1-3 are in pounds sterling, and are equal to the average nominal annual hut tax assessment by the government between 1899-1902. One observation is dropped in columns 2 and 3, because 1963 census data are not available for one chiefdom, Dibia. Thousands of strangers is the 1963 census count, in thousands, of the number of “indigenous” (e.g. Africans of non-Krio Sierra Leonian descent) residents of the chiefdom not born there. The outcome in column 4 is an indicator for whether the government had given permission to mine in the chiefdom between 1935 and 1940. Trade routes in column 7 are from Mitchell (1962), who maps the major trade routes identified by Governor Rowe during a country-wide expedition in 1895. The railroad in column 8 began operation in 1897; the full route was completed in 1907 and ceased operation permanently in 1974. The major towns in column 9 are Bo, Kenema, and Freetown, the three largest cities by population in 2004; these cities were also prominent in 1900. Predicted literacy in column 10 is 2004 literacy rate by chiefdom of birth, predicted in the census micro data by a linear regression including the variables in columns 4-9 and 12 district fixed effects. Standard errors in this column have been block bootstrapped at the chiefdom level to account for sampling error in the prediction of literacy from the exogenous covariates; predicted literacy was estimated 500 times, drawing with replacement a sample of chiefdoms and all observations within them. The log difference between the mean of the top quartile of number of ruling families and the bottom is $\ln(7.7) - \ln(1.8) = 1.45$.

In columns 1-3, we examine the average annual house taxes assessed by the colonial government between 1898 and 1902. As discussed above, we use this variable as a proxy for economic prosperity at the turn of the 20th century in the area. Since there are no chiefdom-level population estimates for this period, we normalize these taxes by chiefdom area (column 1) and 1963 population (column 2). Though the standard errors are large due to the small sample size, the estimated effects in columns 1 and 2 are small and far from significant, providing no prima facie evidence that the number of ruling families is correlated with prior development outcomes. Moreover, the negative point estimates suggest that if anything, having more ruling families is related to lower tax assessments per capita.[29]

In column 3, we include the number of Sierra Leonians not born in the chiefdom but resident in the chiefdom in 1963 (colloquially known as "strangers") to control for potential migration towards more prosperous chiefdoms in the specification of column 2. This has little impact on our estimates, and there is still no significant relationship between 1900 tax assessments per 1963 population and the number of ruling families.

As we have already indicated, case study evidence suggests that the number of families was largely fixed at the beginning of the 20th century. If this is true, families should not emerge in response to shocks occurring later on in the colonial period. In column 4, we provide some evidence consistent with this idea by showing that the number of ruling families is uncorrelated with a dummy indicating whether mining permissions were given by the government during the country's first mining boom in the 1930s, when diamonds and other precious metals were discovered in many chiefdoms.

In columns 5, 6, 7, 8, and 9 we examine the correlation between the number of ruling families and several geographic (and historical) characteristics that might be correlated with the development potential of a chiefdom. In columns 5-7, we look at the correlation between the number of families and distance to coast, distance to navigable rivers, and distance to the major trade routes mapped by Governor Rowe after an expedition across the country in 1895 (presented

[29]The standard deviation of tax assessment per 1963 population is large, at 29.28 pounds sterling. At the point estimate in column 2, this implies that moving from the mean of the bottom quartile to the mean of the top quartile of the number of ruling families should decrease per capita tax revenues by 0.15 of a standard deviation. Though the confidence intervals on this effect are sizable, their positive regions do not admit large effects. At the upper bound of a 95% confidence interval, the same increase in the number of ruling families should raise per capita tax revenues by only 0.44 of a standard deviation.

in Figure 1.1). In all three columns, the number of ruling families is insignificant statistically and economically negligible.

In column 8, we use distance to 1907 railroad, which was important for agricultural exports during the colonial period. This was built not to follow pre-colonial trade routes, but rather to reach the areas assessed as having the greatest agricultural potential. Here the effect is significant and negative at $\alpha_{fam} = -6.78$ (s.e.=3.27), but the implied magnitude is unlikely to be economically important; moving from the top to bottom quartile of the number of quartiles of the number of ruling families has an implied increase in proximity of only 9.83 kilometers (6.11 miles). In column 9, we use minimum distance to one of the three major towns of Sierra Leone, Freetown, Kenema and Bo. This correlation is also negative and significant, but once again very small in magnitude.

Overall, the results in Table 1.3 show that the number of ruling families is unrelated to proxies for colonial prosperity, but they do raise the possibility that it may be correlated with some geographical determinants of economic development.

In column 10, we provide a rough estimate of the magnitude of the bias that might be resulting from this correlation, focusing on one of our core outcome variables, literacy as measured in the 2004 census. The left-hand side variable in this regression is the predicted value from the regression of literacy on six geographic variables from the earlier columns: distance to trade routes, the coast, rivers, the railroad, the three major towns, and a dummy for the presence of 1930s mining permit; and district fixed effects.[30] This predicted value can be interpreted as the component of contemporary literacy that projects on the geographic factors which potentially influence contemporary development. Regressing this value on the number of ruling families and our controls provides an estimate of the magnitude of the potential bias. Column 10 shows that this potential bias is small at $\delta_{fam} = 0.01$. Though the coefficient is statistically significant at 9%, it is only 1/5th of the magnitude of our estimate of the effect of the number of ruling families on primary education reported in the next section.[31]

[30]We exclude the tax measure from this exercise, because the missing data would cause us to drop 42% of chiefdoms in our sample.

[31]Standard errors in this column have been block bootstrapped at the chiefdom level to account for sampling error in the prediction of literacy from the geographic covariates; predicted literacy was estimated 500 times, drawing with replacement a sample of chiefdoms and all observations within them. In Appendix A.3, we present estimates of the potential bias for a subset of our outcomes.

Even though the magnitude of the estimate in column 10 cannot explain the results we present below, for completeness we also report results including all of these geographic controls.

1.6 Main Results

In this section we present our main results. We first focus on a range of development outcomes, including education, various school enrollment measures, child health outcomes, non-agricultural employment, and measures of asset ownership and housing quality. We then turn to measures of property rights, social capital and attitudes. We also look at the evolution of literacy over time. Our typical regressions are at the individual level and can be written as follows:

$$y_{ic} = \delta_d + \alpha_{fam} \cdot F_c + \gamma_n \cdot N_c + \gamma_a \cdot \text{Amalgamation}_c + \mathbf{X}'_{ic} \cdot \mathbf{fi}_X + \mathbf{W}'_c \cdot \mathbf{fi}_W + \varepsilon_{ic}, \tag{1.3}$$

where i denotes the individual and c the chieftaincy, y_{ic} is the dependent variable of interest, which in many of our specifications is a dummy variable, making this relationship equivalent to a linear probability model. In addition, δ_d denotes the set of 12 district fixed effects; F_c is the log number of ruling families in chieftaincy; N_c denotes the number of chiefs in the history of the chieftaincy that the oral historians could remember in c; Amalgamation$_c$ is a dummy for whether the chieftaincy was amalgamated, as in (1.1) and ε_{ic} is the error term. The vector $\mathbf{X}'_{ic}$, which we include in some specifications, contains the individual-level socio-demographic covariates: age, age squared, and dummies for gender and ethnicity. For each specification, we present one panel (A) that does not include $\mathbf{W}'_c$, the vector of six geographic characteristics potentially correlated with economic historical development discussed above, and one panel (B) that does.

The main coefficient of interest is α_{fam}, the marginal impact of an increase in the log number of ruling families on our outcomes. Throughout, the standard errors we report are robust to heteroskedasticity, and when the data are at the individual level, they are also clustered to allow for arbitrary correlation across individuals within a given chieftaincy. In Appendix Figure A.1 we show that our core results are also statistically significant under permutation-based p-values that do not rely on large sample asymptotics.

1.6.1 Effects on Development Outcomes

Educational Outcomes Table 1.4 presents results using individual-level data from the 2004 census and the NPS on three educational outcomes: literacy, primary school attainment and secondary school attainment. In this table, each left-hand side variable is binary. All columns include district fixed effects and controls for the number of chiefs recalled and the amalgamation dummy.

In Panel A, all columns show a substantial and statistically significant relationship between the log number of families and educational outcomes. Column 1, which does not include demographic controls, shows a significant positive relationship between the number of ruling families and the likelihood that a person over 12 is literate (in the census). The coefficient estimate is $\alpha_{fam} = 0.051$ (s.e.=0.013). The coefficient on the control for amalgamation is negative, as expected. The number of chiefs recalled has a tightly estimated effect of zero, giving us reassurance that recall bias on the part of the oral historians is not driving our results.

The second column, which additionally includes controls for an individual's age, age squared, gender and ethnicity, yields an estimate of $\alpha_{fam} = 0.046$ (s.e.=0.011). Column 3 returns to the issue of functional form already discussed in Table 1.2 and adds to the specification in column 2 the number of ruling families (in addition to its log). The log coefficient remains significant and largely unchanged, while the effect of the number of families is estimated as a relatively precise zero. This supports the notion that it is increases in the number of ruling families starting from a low base that matter for economic outcomes and reinforces our choice of functional form.

The estimates for primary and secondary school attainment using census data in columns 4 and 6 are also very similar. They are statistically significant at less than 1% and economically large. They imply that moving from the bottom to the top quartile of the number of ruling families (from 1.8 to 7.7) would increase the likelihood of literacy, primary school attainment and secondary school attainment by about 7 percentage points. Reassuringly, the estimates from a separate dataset—the NPS sample of household heads, with significantly lower overall educational attainment than the census average—are very similar. This can be seen in columns 5 and 7, where the estimates are statistically indistinguishable from those from the census.

Figure 1.6.1 compares the magnitude of these estimates to the potential omitted variable

Table 1.4: *Educational outcomes, results*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable		Literacy		Primary school attainment		Secondary school attainment	
Source	Census	Census	Census	Census	NPS	Census	NPS
Panel A: Baseline specification							
Ln(# of ruling families)	0.051	0.046	0.047	0.048	0.054	0.036	0.044
	(0.013)	(0.011)	(0.024)	(0.012)	(0.024)	(0.009)	(0.020)
# of ruling families			-0.000				
			(0.006)				
Amalgamation	-0.038	-0.033	-0.032	-0.033	0.030	-0.023	0.003
	(0.021)	(0.018)	(0.018)	(0.019)	(0.045)	(0.015)	(0.040)
Number of chiefs recalled	0.000	0.000	0.000	0.000	0.006	0.000	0.005
	(0.003)	(0.002)	(0.002)	(0.003)	(0.007)	(0.002)	(0.006)
R^2	0.008	0.131	0.131	0.160	0.122	0.072	0.096
Panel B: Baseline specification with additional geographic controls							
Ln(# of ruling families)	0.038	0.034	0.026	0.036	0.038	0.028	0.032
	(0.011)	(0.010)	(0.022)	(0.010)	(0.023)	(0.008)	(0.018)
# of ruling families			0.002				
			(0.005)				
Amalgamation	-0.028	-0.024	-0.025	-0.023	0.033	-0.017	0.005
	(0.017)	(0.015)	(0.015)	(0.015)	(0.038)	(0.012)	(0.035)
Number of chiefs recalled	0.001	-0.000	-0.000	-0.000	0.004	0.000	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.002)	(0.005)
R^2	0.010	0.133	0.133	0.163	0.126	0.073	0.100
Observations	2,623,140	2,622,861	2,622,861	2,612,970	5,041	2,082,366	5,041
District fixed effects	YES	YES	YES	YES	YES	YES	YES
Demographic Controls	NO	YES	YES	YES	YES	YES	YES

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. Dependent variables are dummy variables $\in \{0, 1\}$ indicating an individual's literacy, primary school attainment or secondary school attainment. Individuals are matched to chiefdom of birth. For literacy and primary school attainment, all individuals above the age of 12 are included; for secondary school attainment all individuals above the age of 18 are included. Demographic controls are age, age squared, and gender and ethnicity dummies. The specifications in Panel B, in addition, include six geographic controls: a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown.

bias estimated in the last section. The top panel plots the relationship between literacy and the number of families, controlling for demographic factors and district fixed effects, estimated in Panel A, column 2 of Table 1.4. An observation here corresponds to the average literacy for a given chiefdom. The log specification is shown to fit well, as was confirmed in column 3 of Table 1.4. The bottom panel shows graphically the potential bias estimated in column 10 of Table 1.3 with literacy predicted using the six geographic variables. Though the relationship is upward sloping, it is much shallower and cannot explain much of what we see in Panel A. Even at the upper bound of a 95% confidence interval, the potential bias shown in Panel B can explain less than half of the relationship.

An alternative way to see this is in Panel B of Table 1.4, which replicates the specifications in Panel A, including the geographic correlates of development discussed above. Here, our preferred specifications with district fixed effects and demographic controls (and without including both the log and the level of the number of ruling families) in columns 2, 4 and 6 continue to be precisely estimated and statistically significant, and only fall by approximately 1 percentage point, which is comparable to the magnitude of the potential bias shown in Figure 1.6.1.

Child Health Outcomes In Table 1.5, we study the impact of the number of ruling families on health using the DHS sample, which contains information on the weight for height and anemia levels of children under five years of age. These are all outcomes that are both direct measures of poverty and have been linked to socioeconomic outcomes later in life (see Strauss and Thomas, 2007, for a review). We begin with Panel A. Column 1, which focuses on the weight for height Z-score and is again without demographics controls, leads to an estimate of $\alpha_{fam} = 0.212$ (s.e.=0.117), significant at 7%. Weight for height Z-scores are the preferred measure of current nutritional status for children under 5 (SSL and IFC Macro, 2008). In column 2, which additionally controls for the age, primary school attainment and ethnicity of the mother, the estimate is very similar. These estimates imply that moving from the bottom to the top quartile of the number of ruling families increases a child's height for weight Z-score by 0.31, nearly a third of a standard deviation.

In columns 3 and 4 the left-hand side variable is a dummy for whether the child tested positive for severe or moderate anemia in a hemoglobin test. We again find significant results with

Table 1.5: *Health outcomes for children under five, results*

	(1)	(2)	(3)	(4)
Dependent variable	Weight for height Z-score		Moderate to severe anemia	
Panel A: Baseline specification				
ln(# of ruling families)	0.212	0.211	-0.099	-0.091
	(0.117)	(0.117)	(0.041)	(0.040)
R^2	0.045	0.052	0.055	0.066
Panel B: Baseline specification with additional geographic controls				
ln(# of ruling families)	0.189	0.167	-0.136	-0.129
	(0.127)	(0.132)	(0.039)	(0.039)
R^2	0.052	0.059	0.067	0.077
Number of observations	1,521	1,519	1,423	1,421
Number of chiefdoms	116	116	114	114
District fixed effects	YES	YES	YES	YES
Mother controls	NO	YES	NO	YES

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. All specifications include number of chiefs recalled and an amalgamation dummy. Children are matched to chiefdoms on chiefdom of current residence. Z-scores calculated using the World Health Organization Child Growth Standards (2006). Moderate to severe anemia is a dummy variable $\in \{0,1\}$ indicating moderate to severe anemia was detected in a hemoglobin test. Mother controls are ethnicity dummies, age and age squared. The specifications in Panel B, in addition, include six geographic controls: a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown.

economically meaningful implications. For example, moving from the lowest to highest quartile of the number of ruling families decreases the likelihood of a child having severe or moderate anemia by 13 percentage points. In Panel B where we include the six geographical correlates of economic development from Table 1.3, the magnitude and significance of the results for body mass and weight for height diminish modestly, but for anemia, they increase. As above, this pattern suggests that our main results are unlikely to be driven entirely by omitted variables.

Economic Outcomes Table 1.6 presents results for a variety of contemporary economic outcomes from the census, the DHS, and the NPS. In column 1, we use the fraction of the population working outside agriculture. Though Sierra Leone's chiefdoms are predominantly agrarian, non-agricultural employment for those currently residing in the chiefdom is a useful proxy for contemporary economic development. Here, we see a statistically significant (at 5%) and economically meaningful association between the number of ruling families and non-agricultural employment within the chiefdom. Moving from the bottom to the top quartile of the number of ruling families increases non-agricultural employment in the chiefdom by 2.3 percentage points off a base of 11 percent.

In column 2, we examine an index of wealth comprised of asset ownership and housing quality constructed by DHS researchers (recall that this variable is matched to chiefdom of residence as we do not have chiefdom of birth in the DHS). Here we find a positive and significant effect, of approximately 1/5 of a standard deviation. In columns 3 and 4, we examine indices of asset wealth and housing quality we constructed from the NPS as described above. Regressions using these unweighted indices are equivalent to Kling, Liebman and Katz's (2007) "mean effects approach". We find positive and statistically significant effects on both asset wealth and housing quality indices. The next row of the table reports the p-value from a χ^2-test of the hypothesis that the coefficient on the log number of families is zero in each one of the (seemingly unrelated) regressions of each component of the index on this variable and controls. These regressions are presented in Appendix Table A.5. These tests provide fairly strong support for the hypothesis that at least one of the asset and housing quality measures is significantly related to the log number of families.

1.6.2 Literacy over Time

We next investigate the timing of literacy effects already documented in Table 1.4, providing some insights into when economic differences across chiefdoms began to emerge. To do this, we run separate regressions of literacy among different birth cohorts on the log number of families using data from the 1963 and 2004 censuses. Figure 1.6.2 plots these coefficients, and Appendix Table A.4 reports them.

The pattern shown in Figure 1.6.2 is in line with the history of the chieftaincy institution. The paramount chiefs were the arm of government through which schools in Sierra Leone were first

Table 1.6: *Economic outcomes, results*

Dependent variable	(1) Non-ag. employment	(2) Asset wealth index	(3) Asset wealth index	(4) Housing quality index
Source	Census	DHS	NPS	NPS
Panel A: Baseline specification				
ln(# of ruling families)	0.016	0.260	0.028	0.058
	(0.008)	(0.136)	(0.010)	(0.023)
χ^2-test p-value			[0.068]	[0.011]
R^2	0.051	0.057	0.063	0.094
Panel B: Baseline specification with additional geographic controls				
ln(# of ruling families)	0.012	0.199	0.025	0.038
	(0.006)	(0.131)	(0.010)	(0.020)
χ^2-test p-value			[0.067]	[0.026]
R^2	0.052	0.080	0.066	0.105
Observations	2,790,000	4,994	5,054	5,077
Chiefdoms	149	117	149	149
District fixed effects	YES	YES	YES	YES
Demographic controls	YES	YES	YES	YES

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. All specifications include number of chiefs recalled and an amalgamation dummy. Demographic controls are age, age squared, and gender and ethnicity dummies. The specifications in Panel B, in addition, include six geographic controls: a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown. Individuals are matched on chiefdom of birth, except in column 2, where they are matched on chiefdom of residence. The dependent variable in column 1 is $\in \{0,1\}$, in columns 2 and 4 $\in [0,1]$ and in column 3 $\in [0,5]$. Column 1 includes all individuals above the age of 10, and is a dummy for employment in teaching, medical work, security, utilities, manufacturing, construction, trade, hospitality, transportation, or financial industry, rather than fishing, farming or forestry. The DHS asset wealth index is derived from a principal components analysis and included with the DHS data. The NPS asset wealth index is an unweighted average of dummies for the ownership of a bicycle, generator, mobile phone, a car, truck or motorcycle, fan, radio, umbrella, and television. The NPS housing quality index is an unweighted average of three dummies indicating ownership of a cement or tile floor, a cement or tile wall, and a zinc or tile roof. Brackets show the p-value from a χ^2-test of the hypothesis that the coefficients on log number of families are all zero in a set of (seemingly unrelated) regressions using each component of the index. These regressions are presented in Appendix A.5.

established in the early 20th century. One of the first government schools, the Bo Government Secondary School, was established in 1906 and funded explicitly from chiefs' contributions. Tax records at Fourah Bay College show agreements between district commissioners and chiefs across the country indicating the amount of tax revenue that would be donated to local schools. Though this authority over schools was established in 1896, it took time for the ruling families and paramount chiefs to consolidate and exercise their new powers. Cartwright (1970) documents that paramount chiefs started dominating appointments to the Legislative Council during the 1950s and early 1960s, when it was in charge of the allocation of educational spending. In this light, it is plausible for divergence across chieftaincies to also have emerged during this period.

1.6.3 Property Rights

The ATS allows us to examine the relationship between the number of ruling families and property rights over agricultural land. Because property rights arrangements may vary across crops, we restrict our analysis to farms on which rice is grown. 87% of agricultural households in Sierra Leone farm rice, and the crop has cultural importance as the national staple (SSL and IPA, 2011). We also control for rice ecology, a key determinant of productivity.[32]

We present our results in Table 1.7. In columns 1 and 2, we investigate whether households in chiefdoms with more ruling families are more or less likely to have had to ask the chief for permission to use their land. The outcome here equals 1 if the household had to ask permission from a traditional authority member to use the plot. It equals 0 if the household has a traditional right of sale or if the plot has been leased from someone other than a member of the traditional authority. In both columns, we find a statistically and economically significant effect of $\alpha_{fam} = -0.058$ (s.e. = 0.026) and $\alpha_{fam} = -0.053$ (s.e. = 0.027) respectively. These indicate that the potential for competition among ruling families tends to reduce the influence of chiefs over land use.

The basic tenets of land law in Sierra Leone were established by the Provinces Land Act of 1927, which gives the chiefdom administration the authority to regulate leases of land to "strangers"

[32]In Appendix Table A.8 we show that ecology itself is unrelated to the number of ruling families.

Table 1.7: *Property rights, results*

	(1)	(2)	(3)	(4)
Dependent Variable	Permission from chief	Permission from chief	Right to sell	Right to sell
Panel A: Baseline specification				
ln(# of ruling families)	-0.058	-0.053	0.021	0.010
	(0.026)	(0.027)	(0.034)	(0.035)
Stranger	0.160	0.202	-0.196	-0.290
	(0.023)	(0.047)	(0.025)	(0.050)
ln(# of ruling families) × Stranger		-0.032		0.072
		(0.032)		(0.036)
R^2	0.135	0.135	0.200	0.200
Panel B: Baseline specification with additional geographic controls				
ln(# of ruling families)	-0.044	-0.039	0.038	0.027
	(0.017)	(0.017)	(0.035)	(0.036)
Stranger	0.156	0.192	-0.200	-0.292
	(0.024)	(0.052)	(0.025)	(0.051)
ln(# of ruling families) × Stranger		-0.028		0.071
		(0.034)		(0.037)
R^2	0.153	0.153	0.205	0.206
Observations	8,417	8,417	8,360	8,360
District fixed effects	YES	YES	YES	YES
Demographic controls	YES	YES	YES	YES
Ecology Fixed effects	YES	YES	YES	YES

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. An observation is a plot on which rice is grown. All specifications include number of chiefs recalled and an amalgamation dummy. Demographic controls are age, age squared, and gender and ethnicity dummies. The specifications in Panel B, in addition, include six geographic controls: a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown. Stranger is a dummy variable indicating that the individual was not born in the chiefdom. Ecology fixed effects are dummies for upland, inland valley swamp, mangrove swamp, boli land, and riverrine area. Regressions are restricted to plots managed by the household head (87% of the sample), as ethnicity and stranger status are only available for these plots. 11% of plots are managed by a stranger. The sample covers 142 of 149 chiefdoms.

(those not born in the chiefdom) or to those without customary land rights in the chiefdom.[33] In column 2, we find that the effect is stronger for strangers, as the law suggests should be the case, though the result is not significant.

In columns 3 and 4 we examine rights of resale. In column 3 we find a positive but statistically insignificant relationship between the log number of ruling families and the likelihood that a household can sell its land. Strangers, as expected, are 20% less likely to have the right to sell, and this coefficient is highly significant statistically. In column 4 we include an interaction between the stranger dummy and the log number of ruling families. More importantly, there is statistically (at 5%) and economically significant effect of the log number of ruling families on the ability of strangers to resell, with $\alpha_{fam} = 0.072$ (s.e. = 0.036). Moving from the bottom to top quartile of the number of ruling families increases this likelihood by 10%.

1.6.4 Social Attitudes, Bridging and Bonding Social Capital and Collective Action

Two questions in the NPS allow us to study the attitudes of citizens to institutions of chief's authority. The questions were carefully designed so as not to lead respondents towards one answer or another. Respondents were given two statements in the local lingua franca, Krio, and asked to say which was closest to their view. They could either agree with one, both, or none. In the first question they were given the statements:

1. As citizens, we should be more active in questioning the actions of leaders.
2. In our country these days, we should have more respect for authority.

Our first attitude variable is a dummy for whether they agree with statement 2. This question was designed explicitly to measure citizens' attitudes towards questioning chiefs and other elites in rural areas. A second question had the statements:

1. Responsible young people can be good leaders.
2. Only older people are mature enough to be leaders.

[33]For a detailed discussion of land law in Sierra Leone, see Unruh and Turray (2006).

This question is particularly relevant because, as is discussed in Richards (1996), the elder/youth divide in Sierra Leone is often one of the most salient ways to distinguish those associated with the power structure of the chieftaincy (the elders) and those outside of the power structure (the youth).[34] We create a second dummy indicating whether the respondent agrees with item 2 in this question.

Table 1.8 reports the results. The first two columns refer to "respect for authority" and the next two are about "only older people can lead". Columns 1-2 show that with or without demographic controls chieftaincies with more ruling families report lower respect for authority. These effects are all significant at 5%. Columns 3-4 show similar effects for the second variable, indicating greater willingness to accept young leaders in chieftaincies with more ruling families.

These results are rather surprising at first blush. If more powerful paramount chiefs are responsible for poorer development outcomes, one would expect attitudes towards the institutions of their power to be unfavorable.[35] But this is the opposite of the pattern here.

We next examine the impact of the number of ruling families on measures of social capital from the NPS. The survey contains a variety of measures of social capital, from which three groups of activities can be distinguished. The first, consisting of attendance at a community meeting, attendance at a local council meeting and attendance at meetings with the chief, proxies for—using the terminology of Putnam (2000)—"bridging" social capital which concerns links between citizens and the elites. These activities partly represent investments by citizens in building relationships with elites in the chiefdom.

The second group of activities proxy for "bonding" activities used to build social capital between people of similar social status. Here we use all ten groups in which an individual could have claimed membership in the NPS.[36] A few of these groups are particularly salient. Rotating credit and savings associations have been widely studied in other contexts and have broader

[34] In fact, any person under the age of 50 is often called a "youth" with significant consequences for power and politics (and the civil war is often portrayed as a rebellion of youths against elders; see in particular Richards, 1996, Humphreys and Weinstein, 2008, Mokuwa, Voors, Bulte and Richards, 2011, and Peters, 2011).

[35] In Appendix Table A.10 we show that these results hold for the subset of individuals residing in the chiefdom in which they are born, suggesting that these effects are not due to selective migration.

[36] Individuals were asked if they were members of a school management group, a labor gang, a secret society, a women's group, a youth group, a farmer's group, a religious group, a savings or credit group (osusu), a trade union or a political group.

Table 1.8: *Attitudes, results*

	(1)	(2)	(3)	(4)
Dependent variable	Agree one should respect authority		Agree only older people can lead	
Panel A: Baseline specification				
ln(# of ruling families)	-0.085	-0.084	-0.054	-0.059
	(0.028)	(0.028)	(0.022)	(0.022)
R^2	0.047	0.052	0.031	0.048
Panel B: Baseline specification with additional geographic controls				
ln(# of ruling families)	-0.089	-0.088	-0.057	-0.059
	(0.029)	(0.028)	(0.021)	(0.022)
R^2	0.049	0.053	0.032	0.049
Observations	5,167	5,077	5,167	5,077
District Fixed Effects	YES	YES	YES	YES
Demographic controls	NO	YES	NO	YES

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. All specifications include number of chiefs recalled and an amalgamation dummy. Demographic controls are age, age squared, and gender and ethnicity dummies. The specifications in Panel B, in addition, include six geographic controls: a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown. Individuals are matched on chiefdom of birth.

economic interest. Labor gangs, or groups of young men who get together and collectively sell their labor on farms or on construction projects, are an important institution in Sierra Leone. Secret societies are heavily involved in the spiritual and cultural life of the communities but also play important roles in dispute resolution and the allocation of land and other resources. It has been argued, for example by Little (1965, 1966), that they can act as a check on the political power of chiefs, though he presents little more than circumstantial evidence for this. Little's work points out that while these variables proxy for "bonding" capital, they may also contain an element of "bridging" capital as well. Particularly in school committees and secret societies, citizens may form relationships with the elite and the paramount chief, as well as with one another.

The final category of activity, collective action, includes two variables, participation in the last month in "road brushing" or the cutting of bush along the road to make it navigable, and in "communal labor" or work given for free to a community project. Both can be seen as the voluntary provision of a public good and indicative of a community's ability to engage in collective action. "Road brushing" is of particular interest as it is the same indicator used to proxy for collective action by Glennerster, Miguel and Rothenberg (2013) in their investigation of the connection between ethnic fractionalization and collective action in Sierra Leone.

We construct ("mean effects") indices for each category of activities from all available variables. Panel A of Appendix Table A.7 reports the correlations between our three indices, and a few of the underlined variables, and confirms that the three indices are only weakly correlated and so capture different aspects of social capital.

Table 1.9 shows a negative impact of the number of ruling families on all of these measures of social capital. The effects on all our indices are negative and highly significant, as are the effects on the individual outcomes of interest. For example, for attendance of community meetings, the coefficient estimate is $\alpha_{fam} = -0.086$ (s.e.=0.024), while for the bonding activities such as membership in labor gangs or secret societies, the coefficients are $\alpha_{fam} = -0.069$ (s.e =0.022), and $\alpha_{fam} = -0.051$ (s.e.=0.026), respectively. There is a similar negative impact on participation in road brushing with a coefficient estimate of $\alpha_{fam} = -0.085$ (s.e.=0.028). All of these are economically and quantitatively significant effects.

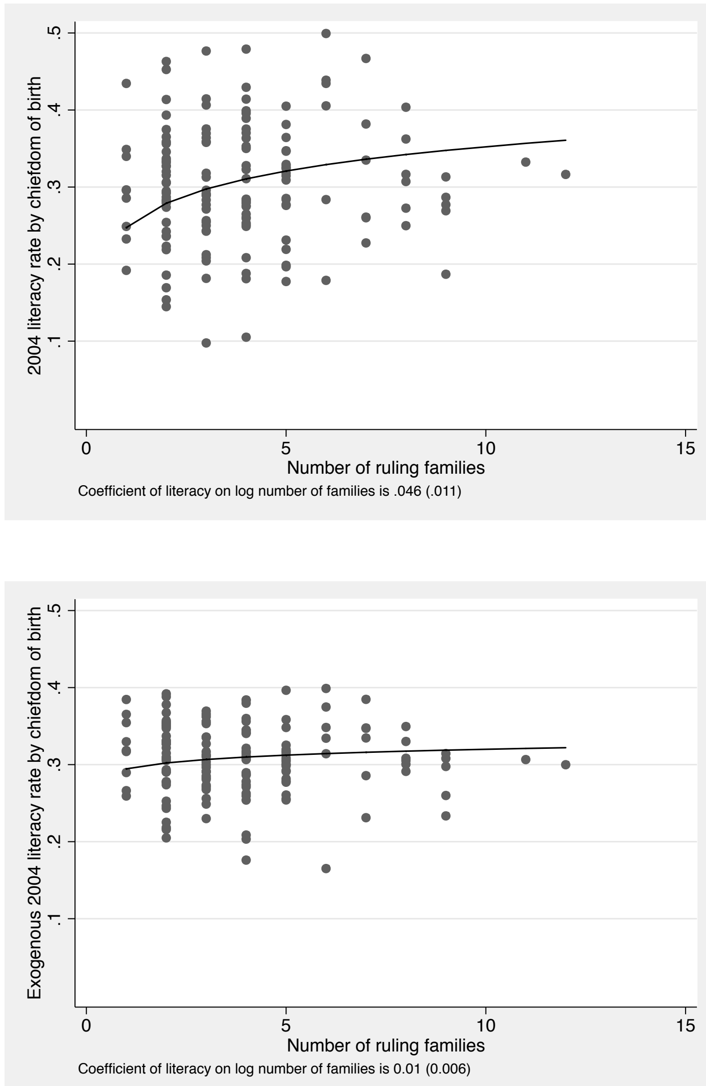

Figure 1.3: *Fitted relationships between actual and predicted literacy and the number of ruling families.*

Notes: The top panel presents the empirical means of 2004 literacy in chiefdom of birth plotted by the number of ruling families. The fitted curve corresponds to the model in column 2 of Table 1.4, which uses the log number of ruling families and controls for district effects, the number of seats observed, an amalgamation dummy, age, age squared, gender and ethnicity fixed effects. The bottom panel shows the means of literacy predicted using six geographic correlates of developmentab: the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown. The fitted curve corresponds to the model in column 10 of Table 1.3.

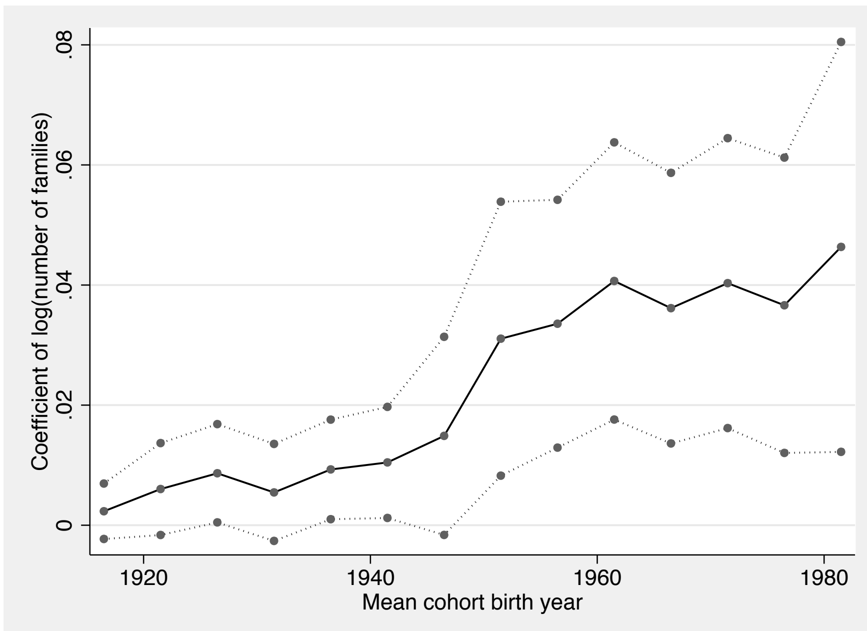

Figure 1.4: *Effect of log number of ruling families on literacy by five year birth cohorts.*

Notes: The dotted lines give a 95% confidence interval. Specification is OLS using chiefdom aggregates with controls for amalgamation, number of seats observed and district fixed effects. Cohorts born before 1953 are observed in the 1963 census, in which one chiefdom, Dibia, has missing data. The first cohort, plotted at the year 1914, includes anyone born before 1918.

Table 1.9: *Social capital activities, results*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Bridging capital index	Attended community meeting	Bonding capital index	Savings and credit group member	Labor gang member	Secret society member	Collective action index	Participated in road brushing
Panel A: Baseline specification								
ln(# of ruling families)	-0.063	-0.086	-0.038	-0.033	-0.069	-0.051	-0.072	-0.085
	(0.018)	(0.024)	(0.008)	(0.015)	(0.022)	(0.026)	(0.019)	(0.028)
χ^2-test p-value	[<0.001]		[<0.001]				[0.001]	
R^2	0.126	0.083	0.102	0.041	0.083	0.072	0.122	0.118
Panel B: Baseline specification with additional geographic controls								
ln(# of ruling families)	-0.061	-0.093	-0.041	-0.038	-0.062	-0.067	-0.079	-0.092
	(0.019)	(0.024)	(0.008)	(0.015)	(0.021)	(0.025)	(0.019)	(0.027)
χ^2-test p-value	[<0.001]		[<0.001]				[<0.001]	
R^2	0.128	0.085	0.105	0.044	0.092	0.075	0.123	0.119
Observations	4,499	5,035	4,070	5,056	5,060	5,050	4,976	5,049
District fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Demographic controls	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. All specifications include number of chiefs recalled and an amalgamation dummy. Demographic controls are age, age squared, and gender and ethnicity dummies. The specifications in Panel B, in addition, include six geographic controls: a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown. Individuals are matched on chiefdom of birth. All outcome variables are $\in [0,1]$. The bridging index is the unweighted mean of dummies for whether respondent has recently attended a community meeting, a meeting organized by the local council and a meeting organized by the paramount chief. The bonding index is the unweighted mean of dummies for whether the respondent is a member of a school management group, a labor gang, a secret society, a women's group, a youth group, a farmer's group, a religious group, a savings or credit group (osusu), a trade union or a political group. The collective action index is the unweighted mean of dummies for whether the respondent has participated in road brushing or contributed labor to a community project in the past month. Brackets show the p-value from a χ^2-test of the hypothesis that the coefficients on log number of ruling families are all zero in a set of seemingly unrelated regressions using each component of the index. These regressions are presented in Appendix Table A.6.

Just like the results for the social attitudes, the pattern here is clear but at odds with expectations based on the literature on social capital—which would suggest less social capital when there is less political competition. The results indicate the opposite: when the power of a chief is less constrained by competition with other ruling families, measured social capital tends to be greater. This is true both for bonding and bridging type social capital.[37] Though seemingly contradictory to our evidence on development outcomes, we believe these results are quite plausible in light of the institutional structure of Africa in general and Sierra Leone in particular.

The idea is simple: a bridge can be crossed in either direction, meaning that bridging social capital can be used as a vehicle to assert social control. In this view, powerful chiefs may not just distort the allocation of resources to education or discourage the non-agricultural sector. In order to enhance their control over society, they may also need to monitor it and bring people together so as to tell them what to do. While it is possible that some of these activities are in the collective good, many of them may simply be in the private interest of the chiefs and their families. This point is made explicitly in the anthropological literature on Sierra Leone, in particular by Murphy (1990) and also by Ferme (2001). Murphy emphasizes that in Sierra Leone community meetings—the outcome in column 2 of Table 1.9—are often used as a form of social control, and are used by elites to construct the appearance of governance based on community consensus, when in fact consensus has little to do with their decisions. Murphy (p. 28) writes

> "public forms [of discourse] are often recognized as an illusion masking alternative commitments arranged in secret. ... [A] key attribute of the mature person or a successful group is the ability to strategically construct ... public appearances".

This interpretation may also have relevance for why less constrained chiefs, who apparently inhibit development, command greater authority and respect. The apparent contradiction arises simply because in the process of building bridges between chiefs and their citizens, citizens themselves make specific investments in their relationships with the chiefs, giving citizens an interest in the perpetuation of the institution. Once people have invested in the social network of the chief and entered into a patron-client relationship, they have no interest in seeing his power diluted by, for example, the youth. In fact, they might prefer having it strengthened. Our

[37] Panel B of Appendix Table A.7 shows a generally negative correlation between social capital and development outcomes at the level of chiefdom aggregates, again contrary to expectations.

interpretation is similar to that of Ntsebeza (2005) who examined the role of chiefs in rural South Africa and argued that "traditional authorities derive their authority from their control of the land allocation process, rather than their popularity amongst their subjects ... the need for land ... compelled rural residents willy-nilly to cooperate with the traditional authorities" (p. 22). Ribot (2001) articulates a similar view which could best be summed up as: *legitimacy follows power*.

An alternative possible explanation of our results is that social capital may be higher defensively in chiefdoms with fewer ruling families, as a way of attempting to control and constrain chiefs that are unconstrained by political competition. However, this explanation is not consistent with our result that attitudes towards institutions of the chiefs' authority are also more favorable when there are fewer ruling families. It is also contradicted by the anthropological evidence discussed previously, for example, Murphy (1990) and Ferme (2001).

1.6.5 Robustness to Connections to Chieftaincy Elite

An alternative explanation for our results could be that the number of ruling families is associated with a broader distribution of patronage within the chiefdom that raises the observed means of our outcomes. Under this hypothesis, it would not be better governance driving the results, but rather a different structure of the patron-client network. The NPS allows us to test this hypothesis directly, as it includes measures of connections to the chieftaincy elite, such as whether a respondent is a member of a ruling family, and whether the respondent has a village headman in the household. In Appendix Table A.13 we show that our main results are robust to the inclusion of these variables as controls. In addition, we show that the number of families is not associated with a greater likelihood of having connections to the chieftaincy elite or with variance in the level of inequality between elites and non-elites. In sum, these results suggest that variation in the social structure induced by the number of ruling families is not driving our results.

1.7 Concluding Remarks and Implications

In this paper we investigated the consequences of constraints on the power of chiefs for development in Sierra Leone. In Africa more broadly, where a majority of the population lives in rural areas and where the national state often lacks capacity and the power to "penetrate" society, institutions of local governance may be pivotal in shaping development outcomes. Yet they have received little systematic empirical investigation. Further, though the institution of the chieftaincy in its modern form was often a creation of the colonial state and there have been attempts to demolish it, chiefs still exercise considerable power across the continent.

Based on a unique survey, complemented by field and archival research on the histories of the chieftaincies, paramount chiefs and ruling families of Sierra Leone, we argue that the fixed number of ruling families that could put forward candidates for the chieftaincy is a useful measure of political competition and the institutional constraints on the power of paramount chiefs. Using this measure, we show that for those born in places where there are fewer ruling families a variety of development outcomes are significantly worse.

We argue that less constrained chiefs—who face greater political competition from other ruling families—lead to worse development outcomes because they are freer to distort incentives to engage in economically undesirable activities through their control of land, taxation, regulation and the judicial system. An obvious interpretation of our results is as a confirmation and extension of the intuition of Becker (1958), Stigler (1972) and Wittman (1989) that political competition functions, like market competition, to promote efficiency. Even under the chieftaincy institutions in Sierra Leone that deviate quite radically from those that these authors were concerned with, it turns out that their intuition applies.

Low levels of competition in some chiefdoms may also have contributed to poor governance in Sierra Leone nationally. The chiefs and the tribal authority formed the basis of the electorate for Sierra Leone's Legislative Council before independence and played an important role in Parliament afterwards (Cartwright, 1970). In chiefdoms with fewer families, the officials elected to constrain the power of the state were chosen by those who faced few political constraints themselves.

In contrast to expectations that would naturally follow from these findings, we also found that chieftancies with fewer ruling families have greater levels of both bonding and bridging social capital, generally believed to be associated with better accountability, good governance and superior development outcomes. Though this finding is in stark contrast to the seminal work of Putnam, Leonardi and Panetti, it does resonate with certain patterns observed in other contexts. The role of social capital to act as a basis of repressive uses of political power has long been noted (e.g., Portes, 1988, Satyanath, Voigtlaender, and Voth, 2013). Moreover, a similar pattern has been observed in India by Anderson, François and Kotwal (2011). It is also in line with the interpretation of the social foundations of personal rule in Africa offered by Jackson and Rosberg (1982). Finally we also found that those associated with the elite in chieftaincies with fewer ruling families command greater respect.

Our interpretation of these last two sets of findings is that chiefs that face fewer constraints build social capital as a way to control and monitor society. This mechanism may also induce people to invest in patron-client relations with powerful chiefs, thus giving them a vested interest in the institution. Hence, if in surveys people say that they respect the authority of elders and those in power, this is not a reflection of the fact that chiefs are effective at delivering public goods and services or represent the interests of their villagers. Rather, rural people appear to be locked into relationships of dependence with traditional elites.

It is useful to note that although our evidence comes from a specific country, Sierra Leone, with necessarily unique institutions, there are many commonalities between Sierra Leone and other African countries, particularly former British colonies, suggesting that our conclusions may have broader applicability. The places most similar to Sierra Leone are those in which the pre-colonial societies had "segmentary states" (Southhall, 1956), where pre-colonial states were generally small groupings of villages headed by a chief advised by a committee of headmen.[38] Segmentary states were very common, including the Gisu, the Kiga and the Alur in East Africa.[39] Another system analogous to ours is the Tanganyika Federation of chiefdoms around lake Tanganyika (Richards, 1960). These chiefdoms, similar in size to those in Sierra Leone, were led by a single chief who had a "royal family"—the *banang'oma*—that provided services to his administration and also administered justice. In these chiefdoms there was not more than one royal family, but as

[38]The places most dissimilar to our context are those either with a strong centralized states that were well established before the colonial period or those completely lacking political centralization, even chiefs. In the former category, such as Asante in Ghana, Benin, Hausaland in Nigeria and Buganda in Uganda, the British have had a more limited role in shaping traditional authorities' power. In places with no political centralization, the absence of clear leaders forced the British to appoint leaders with no primary legitimacy at all (Jones, 1970, Afigbo, 1972 on the Nigerian cases). The French chose similar action in south-eastern Cameroon, where they recognized arbitrarily chosen outsiders to be chiefs of the Maka, a group not accustomed to central authority (Geschiere, 1993). In these cases, unlike Sierra Leone, the colonial chiefs could not maintain their legitimacy after independence.

[39]Ferguson and Wilks (1970) describe similar societies in northern Ghana. Pre-colonial societies in many parts of Nyasaland (now Malawi) and Rhodesia (now Zambia and Zimbabwe) were also similar.

colonialism progressed, officials did establish systems of election of chiefs, which forced aspirants to appeal to bases of political support outside the *banang'oma*.

Our findings have various implications for understanding the process of economic and institutional development in Africa. Most significantly, our findings raise the possibility that ideas on the relationship between the nature of politics and social capital developed with reference to societies with advanced economies and relatively strong institutions may have limited applicability to politics in Africa, or at the very least in Sierra Leone. They also suggest caution in the implementation of certain popular policies. For instance, many international aid agencies are now heavily involved in attempts to "strengthen" civil society and build social capital in the hope that these will increase local accountability and public good provision. The World Bank pours millions of dollars into Community Driven Development schemes (for example in Sierra Leone, Casey, Glennester and Miguel, 2012, Liberia, Fearon, Humphreys and Weinstein, 2009 and the Democratic Republic of the Congo, Humphreys, de la Sierra, van der Windt, 2012). However, if traditional civil society is captured by chiefs, efforts to strengthen it without freeing it from the control of traditional elites might just strengthen the power of chiefs. We believe that future research investigating these questions in greater detail would be particularly interesting. A major question is whether interventions that strengthen civil society organizations within a given institutional structure improve governance or further bolster existing institutional arrangements, even if they are dysfunctional.

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Chapter 2

The Allocation of Capital Across Space: Evidence from India 1980-1995

2.1 Introduction

Economic growth has always been accompanied by a reallocation of capital across space. As emphasized by Barro and Sala-i-Martin (1991), Blanchard and Katz (1992), Glaeser et. al. (1992), Acemoglu and Dell (2010), and Gennaioli et. al. (2013a,b) there is great dispersion in the productivity of regions within countries. The movement of capital in response to productivity growth in certain areas relative to others facilitates a process of regional convergence. In the short run however, particularly in developing economies, populations may be less mobile than capital, leading to widening income inequality across space as capital reallocates. A literature on regional income inequality finds that the recent periods of growth in Brazil, China, and India have all been accompanied by an increase in the share of inequality explained by differences across regions rather than within.[1]

As a response to the immobility of labor relative to capital, governments have often responded by reallocating capital across space, often to areas of the country with low levels of urbanization,

[1] In Brazil, Azzoni (2001) finds that between 1939-1995, while overall income inequality decreased substantially, the share of inequality explained by differences between regions has increased from 61 to 81 percent. In China, Kanbur and Zhang (2005) find that the share of income inequality attributable to differences between urban and rural doubled between 1984 and 2000. In India, Trivedi (2003) finds that between 1960-1992 economic growth across states has diverged, as it has become increasingly concentrated in a few states. The phenomenon of regional inequality with growth was observed early on by Williamson (1965).

which often have low wages and low levels of social development (e.g. Renaud, 1981, and Henderson, 1988). This paper studies the welfare effects of perhaps the most salient such policy in a developing economy, the regime of licensing restrictions in India which, in combination with subsidized access to capital and large investment by government owned enterprises in rural areas, placed caps on investment in highly productive urban regions in an attempt to divert capital to rural ones.

The discussion is guided by a new model of industrialization across space, which I call the spatial Lewis model, after Sir W. Arthur Lewis (1954). The model characterizes the process of growth in a region as a structural transition from informal to formal work by a fixed population, accompanied by the gradual accumulation of capital in the formal sector. The central assumption is that as workers are pulled from the informal sector, the outside option of the marginal worker is ever increasing. This generates a continuous version of the "Lewis turning point" phenomenon, that wages are convex in employment. Thus, even if there are external agglomeration economies of scale in production in the region, these economies will eventually be diminishing because of an increasingly scarce labor supply. At low levels of development, additional investment in capital may achieve large economies of scale, because workers can be pulled in cheaply to complement it. At higher levels of development, fewer workers will be pulled in, and gains from scale will be less. This model produces an inefficient competitive spatial equilibrium, in which the gain from relocating capital from highly developed areas to under-developed ones may increase total surplus. This model, I argue, is a useful representation of a country such as India in the 1980s, in which there were many regions with large pools of labor, but very low levels of capital investment.

As a preview of results, I show that the reform of India's industrial licensing regime induced a reallocation of capital from rural to more urbanized regions, and as a consequence induced substantial declines in the formal sector wage bill in rural regions. The welfare effects of the reform were thus heterogeneous. I then use the licensing reform to estimate two structural elasticities: the elasticity of the equlibrium capital stock and wage rate in a region industry to an implicit tax on investment in the region. These elasticities are shown to be higher in absolute value in less urbanized areas, confirming the predictions of the Lewis model; a percentage increase in the capital stock in rural areas can have a disproportionate effect on wages and investments relative to what it would have in urban areas. This suggests that reallocating capital from urban to rural areas may indeed be welfare improving.

This work complements a growing theoretical literature on place-based policies initiated by Glaeser and Gottlieb (2009) and Kline (2010), by discussing the consequences for policy of labor immobility, and by considering the implications for place based policies targeting capital investment and not population. It also adds to the empirical work on place based policies in the U.S. by Busso et. al. (2013) and Moretti and Kline (2013), by studying such policies in a developing country context. Finally, by nature of the topic, this literature adds to the descriptive literature on agglomeration in India in particular in by Lall et. al. (2004), Ryan (2012), Fernandes and Sharma (2012a, 2012b), and Ghani et. al. (2013).

The paper proceeds as follows. In section 2, to guide the subsequent discussion, I develop a spatial Lewis model of industrialization across space. In section 3, I summarize the history of policies in India that distort the allocation of capital across space, and propose a useful way to interpret them in the context of the model. In section 4, I describe the data to be used in the empirical analysis. In section 5, I present reduced from results on the reallocation of capital and real wage bill across space following the reform of the licensing policy. In section 6, I conduct a welfare analysis of placed based policy using model to give context to the empirical results. In particular, the discussion describes when policies such as those implimented by the Indian government could have been welfare improving. In the presence of agglomeration externalities and low rates of migration across regions, as in India, this suggests that the government's policies were potentially welfare enhancing, or at least not as detrimental as one might have assumed. In section 7, I structurally estimate the two key elasticities required for policy analysis and validation of the model. In section 8, I use these elasticities to estimate the welfare effects of three counter factual policies which would induce a reallocation of capital across space. Section 9 concludes.

2.2 A Spatial Lewis Model of Industrialization Across Space.

As a guide to the discussion, I develop a new spatial equilibrium model of industrialization across space, which has three distinct features, each of which matches well the Indian context.

First, within a region, workers choose between working in an informal, labor intensive sector, and in the formal manufacturing sector, in which their labor is combined with capital as in Lewis

(1954).[2] The transition between formal and informal is extremely relevant in India. Hsieh and Klenow (2012) report that in 1989, 71.9 percent of Indian manufacturing employment was in the informal sector. After a period of rapid growth in manufacturing value added, it had fallen to 62.0 percent in 2005. As the model determines the level of the transition from informal to formal production across different regions, I call it a spatial Lewis model.

Second, while workers are mobile between the dual sectors within a region, they are immobile across space. This assumption is appropriate for the 1980 to 1995 period studied in India. Just before our time period, Rosenzweig (1978) finds large wage gaps across regions in the agricultural sector, suggesting that migration then was highly constrained. Later, Banerjee and Duflo (2004) report that in the 1991 Indian census only 14.7 percent of the male population lived somewhere other than where they were born. Case study evidence suggests that migration, when it does occur, happens within small geographic regions for short periods of time (Breman, 1993). Munshi and Rosenzweig (2009) and Morten (2013) argue that migration is low because of the absence of formal insurance products, and thus the heightened value of local social networks for protection against income shocks.

The mobility of workers is usually a crucial assumption in spatial equilibrium models within higher income countries, as migration allows wages and unemployment rates to adjust to changes in local productivity (Blanchard and Katz, 1992). It is precisely because of India's large informal sector, however, and the large pool of labor from which formal sector employment can draw, that migration is likely to be second order for the determination of wages in this context. In this model, wages are determined in spatial equilibrium by the allocation of capital, which is freely mobile across space, and by the ease with which labor can be pulled from the informal sector.

Third, the combination of agglomeration economies of scale in formal sector production and the (endogenously determined) size of the informal sector will determine whether it is welfare enhancing to reallocate capital across space. As will be discussed in greater detail in Section 6, the key intutition here is that if underdeveloped regions with low exogenous productivity can be improved through agglomeration economies, it may be welfare improving to subsidize

[2] In Lewis (1954, pg. 141) informal employment is taken to include agriculture, domestic service, petty trading and "the whole range of casual jobs—the workers on the docks, the young men who rush forward asking to carry your bag as you appear, the jobbing gardener, and the like."

investment in the area, and to fund these subsidies with taxes on areas which are already highly industrialized. Since the elasticity of wages to taxation on investment will be smaller in absolute value in these areas, the loss from taxation may be smaller than the gain in the less developed region.

2.2.1 Model Preliminaries

The Economy The model describes an economy with one tradable output, whose price is the numeraire. Time is indexed by t. There is a set of regions O, each indexed by $d \in \{1, ..., D\}$, where $D = |O|$. There are measure one workers, with a share N_{dt} each living in region d. Wages W_{dt} are set by a labor market clearing condition in each region that equates the wage of the marginal worker in the formal sector to his or her outside option in the informal sector. The capital stock in the economy $\bar{K}_t$ is supplied by an international market with an upward sloping inverse supply curve $R_t = R(\bar{K}_t)$. The marginal return to capital R_t is set by the equilibrium allocation of capital across space.

The Informal Sector and Labor Supply Laborers in each region have one unit of time and must decide whether to spend it working in the formal sector or running their own informal enterprise. In the formal sector, each worker's productivity is homogenous, and each is paid a fixed wage W_{dt}. An informal sector enterprise however yields idiosyncratic profit π equal to its sales. Individual profitability in the informal sector is distributed according to a cumulative distribution function $F(\pi)$ with support strictly above unity, so that there exists a marginal worker with informal sector profits $\tilde{\pi} = W_{dt}$. All workers for whom $\pi < \tilde{\pi}$ prefer to work in the formal sector, and so aggregate labor supply to the sector is given by $L_{dt} \equiv N_{dt}F(W_{dt})$. To parameterize the profitability of the informal sector, let $F(\pi)$ be a given by a Pareto distribution so that labor supply is given by

$$L_{dt} = N_{dt}\left(1 - \left(\frac{1}{W_{dt}}\right)^{\iota}\right) \tag{2.1}$$

with $\iota \in (1, \infty)$. A key feature of this economy is that it includes a continuous version of the Lewis Turning Point, or what can be called the Lewis transition, which is that wages are convex in employment.[3] At low levels of formal sector employment, wages may rise very little as employment expands. As the formal sector grows, however, wages must rise more quickly for it to expand at the same rate, as it must now pull workers from the informal sector who have increasingly profitable outside options. Note that at $W_{dt} = 1$, we have $L_{dt} = 0$, a corner solution with no formal sector.

The Pareto slope parameter ι characterizes the extent of the available outside options in the informal sector, and governs the speed of the transition. Average profit for those who prefer the informal sector is $\frac{\iota}{\iota-1}W_{dt}$. As ι decreases, they have on average an increasingly profitable opportunity in the informal sector relative to the wage rate and so the rate of the Lewis transition is slower. As ι increases, the relative quality of their outside option falls. In the extreme case, as $\iota \to \infty$ the average relative benefit of working informally falls to zero, and full employment in the formal sector can be obtained for any $W_{dt} > 1$.

The Formal Sector and Capital The formal sector is made up of many firms indexed by j that combine capital and labor to produce value added output Y_{dt} using a Cobb-Douglas constant returns to scale production function

$$Y_{dt} = A_{dt} L_{jdt}^{\eta} K_{jdt}^{1-\eta}. \tag{2.2}$$

Fernandes and Pakes (2008) estimate production functions using panel of firms in India using the World Bank Investment Climate survey and fail to reject constant returns under a variety of specifications, suggesting that constant returns to scale is an appropriate model for production at the level of the individual manufacturing firm in India.[4] Aggregate labor and capital demand are given by $L_{dt} = \sum_j L_{jdt}$ and $K_{dt} = \sum_j K_{jdt}$, respectively.

Firms are price takers in the capital and labor markets. Profit maximization by all firms

[3]As in Sen (1966), this model generates this transition between without relying on a zero marginal product of labor in the informal sector, as in the original Lewis model. The phenomenon could be generated in this model with any $F(\cdot)$ that is everywhere concave.

[4]Lall (2004), who uses a different estimation procedure on a different Indian data set, also fails to reject constant or decreasing returns across various industries.

requires that district aggregate capital and labor be chosen in inverse proportion to their costs:[5]

$$\frac{K_{dt}}{L_{dt}} = \frac{W_{dt}}{R_t}\left(\frac{1-\eta}{\eta}\right). \tag{2.3}$$

To clear the labor market in the region, substitute (2.1) into (2.3). This gives the aggregate capital demand function for each region as a function of the cost of capital and the wage rate:

$$K_{dt} = \frac{N_{dt}}{R_t}\left(\frac{1-\eta}{\eta}\right)\left(W_{dt} - W_{dt}^{1-\iota}\right). \tag{2.4}$$

Naturally, capital demand is decreasing in the cost of capital R_t. It is also concave in the wage rate. This is a result of the Lewis transition. As labor becomes more expensive, capital is demanded as a substitute for labor and the capital labor ratio must increase, as shown by (2.3). This effect diminishes however as wages rise. As an increasing share of workers have been pulled from the informal sector, and with each unit of labor that is brought in the wage rate rises faster. Capital is then less valuable because of the upward pressure investment places on wages.

We allow for the Hicks neutral productivity term A_{dt} to vary with external economies of scale. We model these as a single reduced form parameter on the composite input of aggregate labor and capital:

$$A_{dt} = \tilde{A}_{dt}(L_{dt}^{\eta}K_{dt}^{1-\eta})^{\omega_d} \tag{2.5}$$

with $0 \leq \omega_d \leq 1$. We will allow for agglomeration economies to vary across space, with parameter ω_d not necessarily equal across locations. For $\omega_d = 0$, we have constant returns at level of the region.

Finally, the capital in the economy must satisfy the adding up constraint

$$\sum_{d=1}^{I} K_{dt} = \bar{K}_t. \tag{2.6}$$

The equilibrium price of capital R_t is set by setting this quantity equal to the international capital supply curve, clearing the national capital market.

[5]Note that this result does not require the assumption of perfect competition in the output market to obtain. Constant markups in a given region, determined for instance by intraregional trade costs of the iceberg variety, are also consistent with this equation.

2.2.2 Spatial Equilibrium

For a given price of capital R_t, the spatial equilibrium in a given region d is an allocation of capital K_{dt} and wage rate W_{dt} under which workers rationally choose between the formal and informal sector, and under which firms individually maximize profits.[6] For each region d, three equilibria exist.

There is a stable poverty trap equilibrium with $K_{dt} = 0$, $W_{dt} \leq 1$, and hence no employment in the formal sector. The stability of this equilibrium can be seen by examining (2.5). If there is no capital in the region, formal sector productivity is zero.[7] A firm with positive capital investment would make losses, and so capital investment stays at zero. To see that the wage must also be less than one, we must consider two cases of positive K_{dt}, one with positive formal sector employment and one without. Suppose that $L_{dt} > 0$. By (2.1) for labor supply to be positive, W_{dt} must be greater than one. But if this were true the firm would no longer be profit maximizing, since it would be paying a positive amount for labor and receiving no output, so this cannot be an equilibrium. So it must be that $L_{dt} = 0$. By (2.1) for this to be the case it must be that the wage rate is less than one, else some workers would prefer to be in the informal sector.

There are two interior equilibria, each with positive capital investment. Here, the marginal product of capital in the region is set equal to the price of capital

$$MPK_{dt} \equiv (1-\eta) A_{dt} \left(\frac{L_{dt}}{K_{dt}} \right)^{\eta} = R_t \ \forall \ d. \tag{2.7}$$

Substituting (2.3) and (2.5) into (2.7) yields

$$R_t = (1-\eta) \tilde{A}_{dt} K_{dt}^{\omega_d} \left(\frac{R_t}{W_{dt}} \frac{\eta}{1-\eta} \right)^{\eta(1+\omega)} \tag{2.8}$$

which shows that through economies of scale the equilibrium wage will be increasing in capital investment in the region. We subsitute the capital demand equation (2.4) into (2.8) to define the

[6]If the good is not traded internationally, the numeraire price of output is set by setting the sum of expenditure and the sum of output over all regions equal to one another in the national accounting identity.

[7]In this sense our economies of scale stem from a sort of coordination problem between investors and laborers. Laborers must move to the formal sector at the same time that capital owners invest. This is closest in spirit to Marshallian agglomeration economies of scale driven by labor pooling, as are summarized Duranton and Puga (2004) and Henderson (2005). A meta-analysis of empirical work is given by Melo et. al. (2009). These economies are also similar to the multiple equilibria generated by coordination failures discussed by Murphy, Shleifer and Vishny (1989) and Rosenstein-Rodan (1943).

equilibrium wage rate as a function only of the exogenous variables R_t, N_{dt}, and $\tilde{A}_{dt}$:

$$\ln(R_t) = \left(\frac{\omega_d}{1+\eta+\omega(1+\eta)}\right)\left(\kappa_d + \frac{1}{\omega_d}\ln(\tilde{A}_{dt}) + \frac{\omega_d - \eta(1+\omega_d)}{\omega_d}\ln\left(W_{dt}\right) + \ln(1-W_{dt}^{-\iota}) + \ln(N_d)\right) \tag{2.9}$$

where

$$\kappa_d = \frac{(1-\eta)(1+\omega_d)}{\omega_d}\ln(1-\eta) + \frac{\eta-(1-\eta)\omega_d}{\omega_d}\ln(\eta).$$

Observe that the left hand side of (2.9) has an inverted U shape in W_{dt}. This is they key result of the Lewis transition. At low levels of W_{dt}, returns to capital investment are increasing, as labor can be pulled cheaply from the informal sector, which raises productivity through the returns to scale. This effect is ultimately overcome however, as labor in the informal sector becomes scarce. As the labor supply elasticity falls with the level of formal sector employment, returns begin to fall. The spatial equilibria, and this inverted U, are summarized in Figure 2.2.2, which shows the returns to capital, or the right hand side of (2.9) as a function of the wage rate, for the case in which all the population is located in one region. Note that the slope of the curve, and its peak depend only on the parameters η, ω_d and ι.

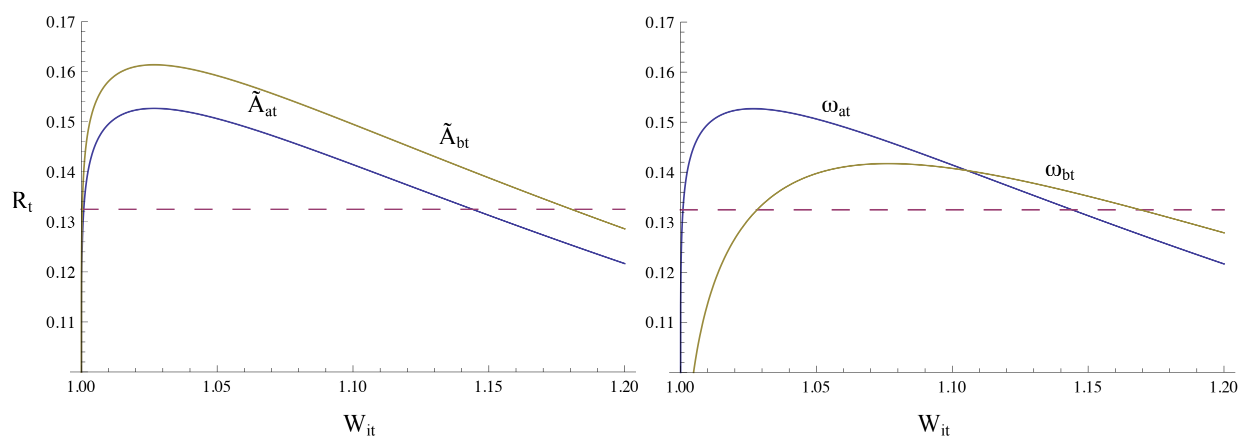

Figure 2.1: *Graphic representation of spatial equilibria.*

Notes: Equilibrium wages are at the intersection points on the dashed line at $R_t = 0.1325$ and at zero. In the left panel $\tilde{A}_{at} < \tilde{A}_{bt}$ and $\omega_{at} = \omega_{bt}$. In the right panel, $\tilde{A}_{at} = \tilde{A}_{bt}$ and $\omega_{at} < \omega_{bt}$. Parameter values are $\eta_i = 0.66$, $\iota = 10$, $N_d = 1$.

It is helpful to understand how the equilibria vary with the exogenous parameters. The left hand panel shows the region for two values of the exogenous productivity parameter, $\tilde{A}_{bt} > \tilde{A}_{at}$, and the three equilibria that exist. The "poverty trap" equilibrium is on the far left with $W \leq 1$, and returns to capital equal approaching zero. The other two equilibria are are given by the intersection of the returns to capital curve with the constant cost of capital R_t. There is an unstable equilibrium with a low level of $W_{dt} > 0$, and a second stable equilibrium with a higher level of $W_{dt} > 0$. The distance between the zero formal sector employment equilibrium and the unstable equilibrium can be interpreted as the magnitude of the "big push" required for the region to begin moving towards the high wage equilibrium. Note here that the higher level of productivity has everywhere a higher level of wages, but an identical slope between wages and the rate of return on capita. The right hand panel shows the same region with $\tilde{A}_{at} = \tilde{A}_{bt}$ and $\omega_b > \omega_a$. Here, the slopes are different. While region b takes a larger big push to reach the unstable equilibrium, once it reaches the high wage stable equilibrium, the slope of wages with respect to returns to capital is higher than in region a.

Inverting the labor supply curve (2.1) shows that we can preform a change of variables and express the equilibrium condition (2.9) in terms the share of the population employed in the formal sector,

$$F_{dt} \equiv \frac{L_{dt}}{N_{dt}} = 1 - \left(\frac{1}{W_{dt}}\right)^{\iota} \quad \Leftrightarrow \quad W_{dt} = \left(\frac{1}{1 - F_{dt}}\right)^{1/\iota}. \tag{2.10}$$

We now summarize the equilibria of the model in the following proposition:

Proposition 1 *In an economy with a positive amount of capital $\bar{K}_t > 0$, there must then exist a set of regions $O_t^K \subset O$ with positive capital stock $K_{dt} > 0$. If all regions in this set have ω_d such that*

$$\omega_d < \frac{\eta}{1 - \eta} \tag{2.11}$$

for each region in this set there exist three equilibrium values of F_{dt}, one with $F_{dt} = 0$, one with an intermediate level of F_{dt} and one with a higher level of F_{dt}.

Proof is given in Appendix B.1.

2.3 Industrial Licensing and Place-Based Industrial Policy in India

Using the model as a guide, we now discuss briefly the history of place-based industrial policy in India, and specifically the place-based component of industrial licensing policy.

2.3.1 Place-based policy in the model

In the model, the policy instrument available to the government is a proportional tax or subsidy, $(1-\tilde{\tau}_{dt})$, on the returns to capital investment in a region. Since many restrictions in India were implemented at the level of the industry as well, we will introduce an industry subscript i, and allow for multiple industries within a region. So that all the intuition of the model above maps to the industry region level, we will assume that each industry has its own formal and informal sector, but that workers are immobile across different industries within a region, allowing for different levels of development in each region industry, F_{idt}. This assumption is justified on the basis of heterogeneous skill requirements across industries. Chamarbagwala and Sharma (2011) document heterogeneity in skill requirements across industries, which provides some support for this assumption.

With the tax, firms' equilibrium condition (2.7) in industry i, region d and time t is now given by

$$MPK_{idt}(1-\tilde{\tau}_{idt}) = R_t \;\forall\; i. \tag{2.12}$$

Rearranging (2.12) observe that this policy is equivalent to setting a region specific price of capital,

$$R_{idt} \equiv R_t(1+\tau_{idt}) = MPK_{idt} \quad \text{where} \quad \tau_{idt} = \frac{\tilde{\tau}_{idt}}{1-\tilde{\tau}_{idt}}. \tag{2.13}$$

In the discussion that follows, we will work with this industry region specific price of capital $(1+\tau_{idt})$ as the policy tool available to the government.

The discussion in section 2 shows that policy makers may use this price to affect formal sector development F_{idt}, or industrialization, on two margins. First, they may foster development in a region on the extensive margin, by providing a big push, lowering the cost of capital to zero temporarily until the unstable equilibrium is reached; after the region will converge on the high wage stable equilibrium. This policy will expand the set of industry regions O_t^K. Second, policy makers may reallocate capital on the intensive margin, between regions in the high wage stable equilibrium. If two regions have the same wage rate, but different ω_d, gains can be achieved by lowering the interest rate in the one with higher ω_d. This policy will be a reallocation of capital within a given set O_t^K.

While policy makers in India did use the rhetoric of the big push to justify policies (see Guha, 2007 for discussion), the scale of these policies was often too small to have plausibly achieved the desired effect. For instance, data compiled by Mohan (2006) shows that from 1981-1993, total expenditure on the Central Investment Subsidy regime—the hallmark big push policy of the government, designed to promote investment in backwards areas—was only 7.55 billion rupees. More generally, Sharma (2008) discusses extreme reluctance of investors to invest in rural areas, even in the presence of subsidies. For this reason, we will focus on the second type of policy, which sought to affect development on the intensive margin, by reallocating capital between regions with positive levels of formal sector development.

The Indian government has pursued a variety of polices which can be seen to have altered the implicit price of capital in a region. Some are taxes, with $\tau_{idt} > 0$, and others are subsidies, with $\tau_{idt} < 0$. Some policies are inherently redistributive, and include elements of both. For instance, Burgess and Pande (2005) study regulations requiring banks to have share of branches and conduct a share of lending in rural areas. While these policies may have subsidized investment rural areas, they also increased the cost of investment in urban areas, effectively raising a tax.

2.3.2 Industrial Licensing

The focus of this paper is on a redistributive policy that placed implicit taxes on investment—values of $\tau_{idt} > 0$. The Industries Development and Regulation Act of 1951 established a variety of controls on industry which were meant to facilitate the administration of industrialization plans promulgated as part subsequent Five Year Plans, which stipulated production targets for key industries (Bhagwati, 1970; Panagariya, 2008). Specifically, under the Act an industrial license was required to (i) establish a new factory, (ii) carry on business in an existing unlicensed factory (iii) significantly expand an existing factory's capacity, (iv) start a new product line and (iv) change location (Aghion, et. al., 2008). Applications for industrial licenses were made to the Ministry of Industrial Development and then reviewed by an inter-ministerial Licensing Committee.[8]

Hazari (1966) shows that the policy was quite restrictive. In 1959 and 1960, 35% of applications were rejected, and the rejected applicants accounted for approximately 50% of the investment value of all applications.

[8]Detailed summaries of the licensing regime are given by Sengupta (1985), World Bank (1989)

Beginning with the *1st Five Year Plan*, "regional balance", or equality across space, in levels of industrialization has been a heavily emphasized policy priority (Government of India, 1951, Ch. 29, Sec. 49). As a consequence, licenses were more difficult to obtain in certain regions, raising the time, and perhaps pecuniary cost investment in these regions. A press note, from April 27, 1983, reads "The Government's policy is to correct regional imbalances and to secure the industrialization of backward areas of the country. Towards this end, government has provided several incentives [including...] preferential treatment in the grant of industrial license" (Chaudhary, 1987). Marathe (1986) emphasizes that "negative criterion" is applied to license applications in "metropolitan areas and specified urban agglomerations." The justification for this approach was typically that international capital supply was extremely inelastic, making the economy, at least from the perspective of investment, relatively closed. Given the relatively fixed capital stock, taxes on investment in urban areas were required to divert it to rural ones.

Licensing restrictions effectively placed a legislative cap on capital investment $\bar{K}_{idt}$ in an industry region that was fixed in the short run. There is an equivalence between this cap and a positive tax τ_{idt} on investment in an industry region, which is summarized in the following proposition:

Proposition 2 *A proportional tax on capital $\tau_{idt} > 0$ is equivalent to a legislative cap on investment $\bar{K}_{idt}$ that, if binding, specifies a constant difference between the marginal product of capital and its cost.*

Proof is relegated to Appendix B.1. From the spatial equilibrium condition (2.9) and the definition of the tax (2.13), however, it can be seen that the tax $\ln(1 + \tau_{idt})$ is the percentage markup of the marginal product of capital over R_t induced by the licensing cap.

2.3.3 Reform

In the early 1980s, the combination of an increasingly "pro-business" turn in the national policy consensus and two unexpected leadership changes following assassinations led to the removal of the industrial licensing policy in different industries over time.[9] Shortly after Rajiv Gandhi's 1984 appointment as Prime Minister following his mother's assassination, a broad reform consensus

[9] For discussion of the political economy of these reforms, see Bardhan, 1984, DeLong, 2004, Rodrik and Subramanian, 2005, and Kholi, 2006

was achieved, and a subset of 3 digit industries were exempted from industrial licensing, or delicensed, in March 1985. Later in 1985 and in 1986, further relaxations followed. A second wave of delicensing occurred in 1991, after Narasimha Rao's appointment as Prime Minister following Rajiv Gandhi's assassination in 1991. As part of a structural adjustment programme following the 1991 balance of payments crisis, most of the remaining industries were delicensed. Panagariya (2008) describes in detail the reform process.

The unexpected timing of these reforms combined with Proposition 2 make them an attractive source of variation in the implicit tax on capital investment $\ln(1 + \tau_{idt})$. Further, since as a matter of policy these implicit taxes were explicitly more binding in urban areas, I hypothesize that the effects of delicensing on capital investment will be more positive in urban areas, and potentially negative in rural areas to which the policy may have temporarily diverted capital. This hypothesis will be tested in Section 5.

2.4 Data and Summary Statistics

The dataset used in this paper to investigate the effects of refrom is a newly constructed panel of 92 formal sector manufacturing industries across 201 Indian regions, from 1980 to 1995. Below, we discuss the nature of the regions and the industries in turn. A brief summary of how the data were constructed is provided here, with further detail in Appendix B.2.

2.4.1 Regions

The 201 regions are contiguous amalgamations of India's districts. These regions were constructed to be the unit of analysis instead of simply using districts because districts are split and amalgamated through the time period studied. The procedure to construct the regions sought to construct the smallest contiguous geographic unit possible over the time period, and is described in detail in Appendix B.2.

Figure 2.4.1 maps the regions and shows their coverage of the country. The areas uncovered were omitted largely due to missing district identifiers in the manufacturing data, as described in detail in Appendix B.2. Even with some omitted however, the sample still covers a large share of the 1980 population, and a large share of the 1980 capital stock. As can be seen on the map too, includes six of the seven largest cities in 2000, missing Ahmedabad, but including Bangalore, Chennai, Hyderabad, Kolkata, Mumbai and New Delhi.

Table 2.1 describes the set of districts used according to a range of baseline variables measured before the licensing reform, and the correlation coefficients of these variables across regions. For all variables, there is tremendous variance across regions. For instance, the average region is 487 kilometers from the coast, but with a standard deviation of 363 across regions. Reflecting their large geographic size, regions are fairly, but not completely urbanized, with average urban share of the population measured in the 1981 census at 20%. Still however, there is substantial variation with a standard deviation of 15 percentage points. Reflecting the good coverage of rural areas in our sample, and the wide extent to which the government classifed regions of the country as backwards, 70% of the regions contained at least one backwards district, using the classifications reported by Mohan (2006). As expected too, urbanization is strongly negatively correlated with being classified as backwards, having a high share of government employment, consistent with the government's stated preference for support for rural areas. Too, the share of total votes going to the Indian National Congress (INC) party in the 1980 national Parliamentary election is also negatively related to urbanization indicating the dissatisfaction of residents of urban areas with INC policies, which may have put them at a disadvantage for industrialization.

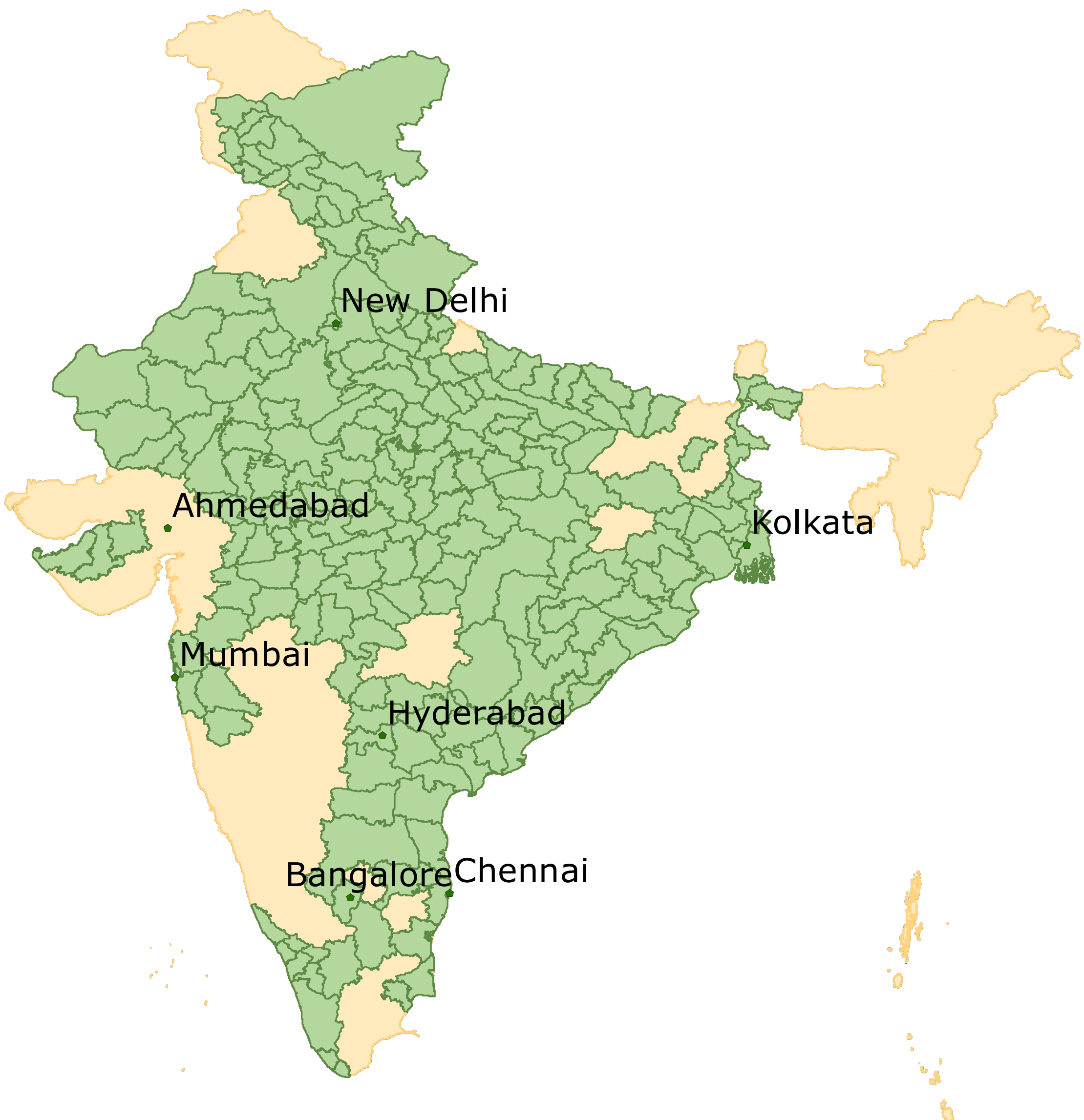

Figure 2.2: *Map of India with the 201 regions used in analysis.*

Notes: Sample regions indiciated in green. Cities indicated are seven largest cities by population according to the 2001 census.

Table 2.1: *Correlation coefficients and means of baseline region characteristics*

	Dist. to coast (km.)	Terrain ruggedness index	Annual no. of riots per 1000 people	Non-ag. credit outlay per capita	Primary educ. attain.	Urban share of pop.	Backwards area	Gov't. share of employ.	INC Parliamentary vote share
Distance to coast (km.)	1.00								
Terrain ruggedness index	-0.03	1.00							
Annual no. of riots per 1000 people	0.14	-0.05	1.00						
Non-agricultural credit outlay per capita	-0.38	-0.01	-0.01	1.00					
Primary educational attainment	-0.54	0.08	0.05	0.58	1.00				
Urban share of population	-0.24	-0.10	0.00	0.81	0.61	1.00			
Backwards area	0.26	0.02	0.09	-0.37	-0.38	-0.49	1.00		
Government share of employment	0.12	0.18	0.18	-0.12	-0.11	-0.14	0.08	1.00	
INC Parliamentary vote share	-0.16	0.10	-0.38	-0.18	0.03	-0.08	-0.12	0.03	1.00
Mean	487	0.54	1.42	1.41	0.35	0.20	0.70	0.20	0.48
Standard deviation	(363)	(0.87)	(0.86)	(3.23)	(0.15)	(0.15)	(0.46)	(0.18)	(0.15)

Notes: Sample is the set of 201 regions used in analysis. Distance to coast is the Euclidean kilometer distance measured from the region centroid. Terrain ruggedness index is calculated using the data and procedure of Nunn and Puga (2012). Annual number of riots is the average of the annual number of riots reported by the Ministry of Home Affairs between 1970-1980, divided by 1971 population. Credit outlay per capita is 1980 non-agricultural credit outlay reported by the Reserve Bank of India in 1980, divided by 1981 population. Primary educational attainment is the share of individuals over age 15 having completed primary education, measured in the 1981 census. Urban share of the population is measured in the 1981 census. Backwards area is a dummy variable indicating whether at least one distirct in the region was eligible for the Central Investment Subsidy scheme in 1983, as reported by Mohan (2005). Government share of employment is the average share of employment in the ASI in government owned establishments between 1980-1983. INC Parliamentary vote share is the share of total votes going to the Indian National Congress party in the 1980 national Parliamentary elections.

2.4.2 Manufacturing and Delicensing

Region industry level manufacturing aggregates are were constructed using the unit-level summary data from the Annual Survey of Industries (ASI). The survey, which is used to construct the national input-output tables and the manufacturing component of national accounts, is a repeated cross sectional sample of all factories—establishments—registered under the 1948 Factories act; essentially all formal sector manufacturing employment. The focus of the spatial Lewis model on the stock of capital in the formal sector motivates a focus on the formal sector in the data. While a number of papers have investgated the cross section of establishments in these data, and the panel of Indian state industries in the data, no papers, to my knowledge, have used the data to construct a panel of industries in geographic regions more dissaggregated than the state.

The sampling frame is based on the lists of registered establishments maintained by the Chief Inspector of Factories in each state; further detail is provided in Appendix B.2. The sample used contains 92 distinct industries, differentiated according to 3-digit National Industrial Classification (NIC) codes. Industries producing goods "not elsewhere classified" within a 2-digit sector were dropped from the analysis, due to concern that the goods produced might be heterogeneous across space. Establishments were linked to regions manually using district identifiers provided with the data by the Indian Central Statistical Office, according to a procedure described in Appendix B.2. A small number of observations in each year were in districts that could not be linked to contiguous regions over time, and so where dropped from the sample. In addition, district identifiers were not available in 1989 or 1990, and so these years must be excluded from analysis.

As described in the Appendix B.2, consistent estimates for the region industry aggregates of value added output, employment in person days, wage bill, capital stock and the number of plants were generated by calculating a sum of these variables across all sampled establishments in a region industry, weighted by the inverse of their sampling probabilities. Capital stock was taken to be the sum of fixed and working capital, or "productive capital," as it is called in the dataset. Real values of value added, the wage bill and the capital stock are calculated by deflating these values by 3-digit industry specific deflators provided by the Reserve Bank of India. As in the model, the wage bill is deflated by the industry price deflator.

Table 2.2: *Region industry summary statistics, by year.*

	1980	1985	1991	1995
Number of industries delicensed	0	35	78	79
Share of real stock capital delicensed	0.00	0.66	0.96	0.96
Share of employment delicensed	0.00	0.42	0.82	0.83
Real capital stock (Millions of Rs.)	17.18	20.39	24.24	28.53
	(3.02)	(3.97)	(5.27)	(6.91)
Person years of employment	337.63	338.08	349.29	360.80
	(77.26)	(78.78)	(86.36)	(92.57)
Number of region industries with positive capital stock	3,342	3,200	3,848	3,792

Notes: Sample includes all region industries with positive capital stock. 92 industries and 176 regions are covered throughout the sample. Real capital stock is the sampling weighted sum of fixed and working capital across all establishments in an industry region year, deflated to 1980 prices using an industry specific capital price index. Person years of employment is the sampling weighted sum of all person days employeed, divided by 365. Standard deviations reported in parentheses.

Data on the removal of industrial licensing restrictions on 3-digit industries over time come from Aghion et. al. (2008), who study the interaction of the reform with labor market regulations. These data have also been used by Sivadasan (2009) and Chari (2011).

Table 2.2 describes the evolution of delicensing over time, as well as the evolution of the sample of region industries over time. Delicensing occurred in two waves, each after unexpected leadership changes. During the first wave, in 1985, 35 of the 92 sample industries were delicensed. After this wave 66% of the real capital stock had been delicensed, and 42% of formal employment had been. The second wave occurred in 1991, when 33 additional industries were delicensed. After this wave, 96% of the real capital stock had been delicensed. There is very little delicensing reform outside of these two leadership changes.

Over this time period, we also see a monotonic increase in both the real capital stock and person years of employment in the average region industry, consistent with increasing growth in the manufacturing sector over this time period. Average real capital stock grows by 66% from 1980-1995, or at approximately 3% annualized. Employment grows more slowly. What is striking is that the variance in real capital stock across space and industries more than doubles over the time period. The variance of employment also increases, but less drastically. These observations are consistent with economic growth in the wake of the reforms, but also widening inequality across regions, a phenomenon that has been observed in India by Ahluwalia (2002), Trivedi (2003) and Topalova (2010).

2.5 Reduced Form Effects of Delicensing Across Regions

In this section we present estimates of the form effects of delicensing. Since, as discussed above, licenses are likely to have been more binding in urban areas, we will specifically allow for heterogeneity in these effects by the region's baseline level of urbanization, as measured by the urban share of the region's population in the 1981 census.

To estimate this effect, we estimate the following regression

$$Q_{idt} = \alpha_{id} + \rho_t + \boldsymbol{\rho_t^U} U_d + \delta D_{it} + \sigma(D_{it} \times U_d) + \varepsilon_{idt} \tag{2.14}$$

where Q_{idt} is the level of either real value added, real wage bill, person years employed, real capital stock, or number of plants in region d, industry, i, and year t. The variable D_{it} is a dummy equal to one if the industry i is delicensed in year t, and zero otherwise. The term U_d is the 1981 urban population share. The sum $\delta + \sigma \times U_d$ gives the effect of delicensing on the average industry in region d. The term α_{id} is a region industry fixed effect, ρ_t is a year effect, $\boldsymbol{\rho_t^U}$ is a year effect that varies by level of urbanization, and ε_{idt} is an error term. The identification assumption that D_{it} is conditionally uncorrelated with ε_{idt} is justified by the unexpected timing of the reforms.

Table 2.3 shows the results. The data set used here is the full balanced panel of 92 industries $\times$ 201 regions $\times$ 13 years, for 240,396 observations. Zeros are observed for industry regions with no output in a given year. Column 1 shows estimates of δ and σ for real value added, column 2, the real wage bill, 3, person years, 4, real capital stock, and 5, the number of plants. In all specifications, δ is negative, and σ is positive, indicating an increasingly positive effect of delicensing in highly urbanized regions, and a negative effect in areas with very low urbanization. These effects are statistically significant at 1% for the real wage bill and the number of plants, and significant at 5% for real capital stock. Finally, in column 6, where the outcome variable is a dummy for whether the industry region had positive output, we also find positive effects, suggesting that the reform did have some effect on the extensive margin, creating new industries in urban areas where some had not existed before, and closing down industries in rural areas.

Table 2.3: *Delicensing and the reallocation of economic activity to urban areas, in levels.*

VARIABLES	(1) Real value added	(2) Real wage bill	(3) Person years	(4) Real capital stock	(5) Plants	(6) Entry $\in \{0,1\}$
Delicensed	-0.36	-0.25***	-6.75	-0.49*	-0.27***	-0.01
	(0.23)	(0.08)	(4.62)	(0.30)	(0.10)	(0.01)
Delicensed × Urbanization	1.85	1.25***	33.79	3.47**	2.28***	0.06**
	(1.20)	(0.42)	(22.23)	(1.45)	(0.48)	(0.02)
R-squared	0.68	0.74	0.74	0.64	0.81	0.58
Number of observations	240,396	240,396	240,396	240,396	240,396	240,396
Industry region fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Year × Urbanization effects	YES	YES	YES	YES	YES	YES
Percentage change in 4th quartile of urbanization	0.06	0.11	0.05	0.14	0.2	0.07
	[0.21]	[0.02]	[0.23]	[0.02]	[0.00]	[0.00]
Percentage change in 1st quartile of urbanization	-0.25	-0.37	-0.15	-0.19	-0.16	-0.03
	[0.18]	[0.01]	[0.20]	[0.27]	[0.13]	[0.55]
Percentage change in 4th quartile of urbanization relative to 1st quartile baseline mean	0.43	0.60	0.25	0.74	1.02	0.24
	[0.21]	[0.02]	[0.23]	[0.02]	[0.00]	[0.00]

Notes: Robust standard errors that allow for arbitrary correlation within industry regions are presented in parentheses. P-values for a test of the null hypothesis that the percentage change is zero are presented in brackets. Outcomes in columns 1-5 are the sampling weighted sums across all establishments in an industry region year. An establishment may have multiple plants. Value added, the wage bill and capital stock measured in millions of 1980 rupees. Entry is a dummy variable indicating positive capital stock in a region industry year. Percentage effets in column 6 are percentage point changes in the likelihood of entry. Urbanization is measured as the urban share of the region population in the 1981 cenus. The 4th quartile mean of this variable is .41, and the 1st quartile mean is .07. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

We interpret the effects in columns 2 and 5 as a *reallocation* of capital and wage bill from regions with low urbanization to those with high urbanization following delicensing. For the capital stock for instance, the average industry in a competely rural region ($U_d = 0$) lost 490,000 rupees from the wage bill, and the average industry in a completely urban area ($U_d = 1$) gained 2.98 million rupees. In order to account fully for these differential average effects, it must also be that the capital stock in the country rose as a result of delicensing. It is clear however that at least some capital was moved between regions. This reallocation of capital is shown graphically in Figure 2.3 which plots the residuals from (2.14) by quartiles of urbanization, with and without delicensing. The movement in capital from low urbanization to high urbanization areas is apparent.

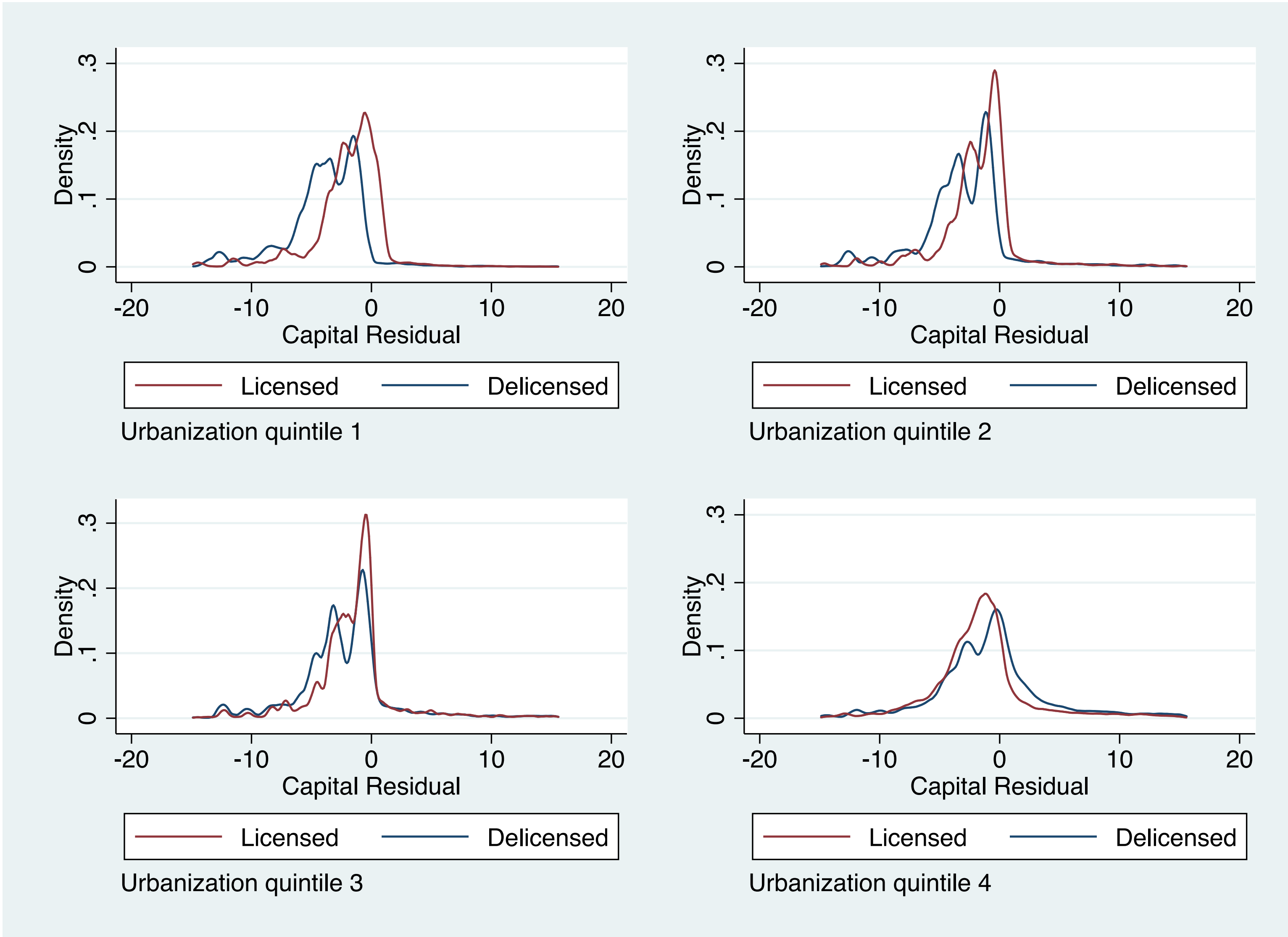

Figure 2.3: *Residualized real capital stock, before and after delicensing, by quartiles of 1981 urban share of population.*

At the bottom of Table 2.3 these effects are restated as percentages, which are shown to be highly non-linear. While regions in the bottom quartile of urbanization lost 37% of their wage bill, highly urbanized areas gained only 11%. Both point estimates of the effects are significant at 1% and 2% respectively. For capital, the highest quartile of urbanized regions saw their capital stock increase by 14%, and the mean industry in the lowest quartile of urbanized regions lost 19% of its capital, though this point estimate effect is not significant at standard levels. In percentage terms then, the reallocation of capital following delicensing disproportionately affected areas with low urbanization; they lost substantially more in percentage terms than those in highly urbanized areas gained.

As a first pass then, it does appear that the repeal of industrial licenses did undo the redistributive aspects of the licensing policy. If the cap on investment in urban regions diverted capital to rural regions, the reforms allowed that capital to reallocate to urban areas. As in the spatial Lewis model, the stock of capital in a region is directly related to the wage bill in that region, wage bills in rural areas also fell as a result of the reform. Further, since rural areas losing capital did so from a much lower base, in percentage terms, they lost substantially more than the urban areas gained.

2.6 Welfare and Policy Analysis

We will now use the model to conduct a welfare analysis of place-based industrial policies that impose a region specific implicit tax or subsidy on capital investment as described above. We will use this analysis to interpret the reduced form results above in terms of welfare, and to ask specifically under what conditions a policy of taxing or subsidizing investment in particular regions would be justified. We will then derive two sufficient statistics required for policy analysis, which will be objects of estimation in the next section.

2.6.1 Aggregate Welfare

To derive the aggregate utility in the economy, we assume workers spend all of their income on consumption of the numeraire good and that individual utility is linear in consumption.[10] The

[10] If one wishes, in this set up one can use the terms aggregate utility and aggregate income interchangeably.

model does not consider variation in the marginal utility of income across space, as Moretti (2011) does not. Since capital is supplied from a perfectly competitive international market, we do not consider the welfare of capital owners. Average indirect utility in a given region industry is then given by

$$
\begin{aligned}
V(W_{idt}) &\equiv \zeta_d + W_{idt} \cdot F(W_{idt}) + [1 - F(W_{idt})] \cdot E(\pi | \pi > W_{idt}) \\
&= \zeta_d + \left(W_{idt} + \frac{1}{\iota - 1} W_{idt}^{1-\iota} \right) \qquad (2.15)
\end{aligned}
$$

where ζ_d is a fixed amenity idiosyncratic to region d.[11] Observe that $\frac{\partial V}{\partial W_{idt}} = F_{idt}$. This is a result of the fact that the marginal worker is indifferent between sectors, and so the welfare effect of a marginal increase in the wage is the same as raising the wage on a fixed share of the population employed in the formal sector. We can now state the welfare properties of the model in the following proposition.

Proposition 3 *Any policy that maximizes the formal sector wage bill within a region industry with positive formal sector employment without reducing the wage bill in others is utilitarian, and maximizes total utility.*

The proof simple and is relegated to the Appendix B.1. The intuition is that wealth can only be created through economies of scale in the formal sector. Since workers are free to choose between sectors, increasing the wage bill in the formal sector is sufficient to raise utility in a region industry. Through the framework of the model, we can then state without reservation that the effect of delicenisng reform was redistributive in terms of utility. Those in rural areas lost in terms of the real wage bill, and those in urban areas gained. While, at least on average, the total wage bill increased, this was not a Pareto improvement.

2.6.2 The Planner's Problem and Sufficient Statistics

We can state the planner's problem as that of choosing in each period a vector of taxes $\boldsymbol{\tau}_{idt}$ that create a wedge between the market price and the private returns to capital in a region industry.

[11] One might allow for the possibility that ζ_d is a function of L_{idt} or K_{idt}, as in Diamond (2012). For instance, pollution might increase as capital investment rises, reducing the utility workers receive from living in the region. With low migration, however, the revealed preference of individuals for differing levels of amenities would be difficult to identify empirically.

Net collections from the tax and subsidy regime are

$$C(\boldsymbol{\tau_{idt}}) = \sum_{d=1}^{I} K_{idt} \cdot MPK_{idt} \cdot \tilde{\tau}_{idt} = \sum_{d=1}^{I} K_{idt} \cdot R_t \cdot \frac{\tilde{\tau}_{idt}}{1-\tilde{\tau}_{idt}} = \sum_{d=1}^{I} K_{idt} \cdot R_t \cdot \tau_{idt}$$

where K_{idt} is an implicit function of τ_{idt} defined by substituting R_{idt} for R_t in (2.9) and (2.4). Because national capital supply is upward sloping, R_t is an implicit function of $\boldsymbol{\tau_{idt}}$, through any general equilibrium effects on $\bar{K}_t$.

We now consider the implications of $\boldsymbol{\tau_{idt}}$ for aggregate welfare. We assume the government rebates net collections from the tax regime (or finances the subsidy regime) with a lump sum transfer (tax) to the population. The social welfare function is then given by

$$\mathcal{V}(\boldsymbol{\tau_{idt}}) \equiv \sum_{d=1}^{I} N_{idt} V(W_{idt}(\boldsymbol{\tau_{idt}})) + C(\boldsymbol{\tau_{idt}}). \tag{2.16}$$

Because W_{idt} and K_{idt} are decreasing in R_{idt} in any stable equilibrium with positive F_{idt}, this function is concave in each τ_{idt}. Taking the first order conditions of $\mathcal{V}$ with respect to each τ_{idt} yields after some algebra and the application of the profit maximization condition (2.3) the optimal value of τ_{idt}:

$$\tau^{\star}_{idt} = -\frac{1 + \frac{\eta_i}{1-\eta_i}\left(\frac{\partial \ln(W_{idt})}{\partial \ln(1+\tau_{idt})} + \xi(\boldsymbol{\tau^{\star}_{idt}})\right)}{\left(1 + \frac{\eta_i}{1-\eta_i}\frac{\partial \ln(W_{idt})}{\partial \ln(1+\tau_{idt})}\right)\xi(\boldsymbol{\tau^{\star}_{idt}}) + \frac{\partial \ln(K_{idt})}{\partial \ln(1+\tau_{idt})}} \forall\ i, t, \tag{2.17}$$

where η_i indicates an industry specific output to labor elasticity in the production function and

$$\xi(\boldsymbol{\tau_{idt}}) = \frac{\bar{\xi}\sum_d^I \frac{K_{idt}}{\bar{K}_t}\frac{\partial \ln(K_{idt})}{\partial \ln(1+\tau_{idt})}}{1 - \bar{\xi}\sum_d^I \frac{K_{idt}}{\bar{K}_t}\frac{\partial \ln(K_{idt})}{\partial \ln(1+\tau_{idt})}(1+\tau^{\star}_{idt})} \tag{2.18}$$

is the elasticity of R_t with respect to any effects on the aggregate capital stock $\bar{K}_t$ created by the tax and subsidy regime. The parameter $\bar{\xi} \equiv \frac{\partial R_t}{\partial \bar{K}_t}\frac{\bar{K}_t}{R_t}$ is the elasticity of international capital supply.

For simplicity of exposition, consider the case of a perfectly elastic capital supply $\xi(\boldsymbol{\tau_{idt}}) = \bar{\xi} = 0$. Here (2.17) reduces to

$$\tau^{\star}_{idt} = -\frac{1 + \frac{\eta_i}{1-\eta_i}\frac{\partial \ln(W_{idt})}{\partial \ln(1+\tau_{idt})}}{\frac{\partial \ln(K_{idt})}{\partial \ln(1+\tau_{idt})}} \forall\ i, t. \tag{2.19}$$

This result is intuitive. Firms do not internalize the effect of their capital investments on productivity, and thus wages. To correct this effect, it is welfare improving to lower the effective price of capital in regions with a lower (in absolute value) elasticity of wages with respect to the district specific cost of capital is higher, conditional on the elasticity of investment of capital to the interest rate.

It is clear then that two elasticities are sufficient for policy analysis. We will denote these as

$$\gamma^K_{idt} \equiv \frac{\partial \ln(K_{idt})}{\partial \ln(1+\tau_{idt})} \quad \text{and} \quad \gamma^W_{idt} \equiv \frac{\partial \ln(W_{idt})}{\partial \ln(1+\tau_{idt})}. \tag{2.20}$$

We will now describe how and why they vary in the spatial Lewis model, before asking the question of whether the competitive equilibrium of the model in fact maximizes welfare.

2.6.3 The properties of γ^W_{idt} and γ^K_{idt}.

We now derive γ^W_{idt} and γ^K_{idt} to show what they depend on. This exercise makes use of two equations presented in section 2. The capital labor ratio implied by profit maximization (2.3), and the spatial equilibrium condition, which defines the wage rate (and thus formal sector labor supply) as a function of the price of capital (2.9). In this equation we substitue for R_t with the actual price of capital faced in the region industry, $R_t(1+\tau_{idt})$.

As a short hand, we will also make use of the equilibrium labor to wage elasticity, which we will call $\zeta(F_{idt})$ and can derive directly from the labor supply curve (2.1) as follows:

$$\zeta(F_{idt}) \equiv \frac{\partial \ln(L_{idt})}{\partial \ln(W_{idt})} = \frac{W_{idt}}{L_{idt}}\frac{\partial L_{idt}}{\partial W_{idt}} = \frac{W_{idt}}{F_{idt}}\frac{\partial F_{idt}}{\partial W_{idt}} = \iota \frac{W^{-\iota}_{idt}}{F_{idt}} = \iota \left(\frac{1-F_{idt}}{F_{idt}}\right) \tag{2.21}$$

The key point to make about this elasticity is that, as discussed above, since $F_{idt} \in [0,1]$, it is decreasing in the level of formal sector development due to the Lewis transition. While the functional form derived here is specific to the Pareto distribution assumed for the productivity of workers in the informal sector, as discussed above any increasingly inelastic labor supply function would generate the Lewis model phenomenon required to obtain our results.

Properties of γ^W_{idt} To drive the elasticity of wages with respect to the district specific price of capital, we take derivative of the left hand side of (2.9), having substituted in the new price of capital, with respect to $\ln(1+\tau_{idt})$, and invert (locally). Here we have assumed using the perfectly elastic international capital supply that there are no general equilibrium effects, and that R_t does not vary with τ_{idt}. In the empirical application, any such effects will be subsumed into year fixed effects.

This derivative yields

$$\gamma^W_{idt} = -\frac{1+\eta_i+\omega_d(1-\eta_i)}{\omega_d(\eta_i-\zeta(F_{idt})-1)+\eta_i}. \tag{2.22}$$

which is always negative in the good equilibrium, where $\zeta(F_{idt}) < (\eta_i - 1) + \frac{\eta_i}{\omega_d}$. As the implicit tax on capital falls, wages rise.

Identity (2.22) makes clear that non-linearity in this elasticity with respect to F_{idt}, which itself moderates the inverse labor supply elasticity ζ, allows for the identification of the agglomeration elasticity. If the region has a high level of F_{idt}, and the equlibrium labor elasticity is low because workers cannot be quickly pulled from the informal sector, wages need not change very much in response to a change in the tax. Conversely, if the equilibrium labor elasticity is high, many workers can pulled in quickly when the tax is lowered, raising wages by improving productivity through the agglomeration economies.

To see this more clearly, consider the case in which, $\omega_d = 0$, and there are constant returns. Here, by (2.3), in response to a shift in the tax on capital, the firm will adjust labor and capital demanded so that the ratio of payments to the two factors is constant. Regardless of the labor supply elasticity, the elasticity of wages respect to the price of capital is constant and equals $-\frac{1+\eta_i}{\eta_i}$. The elasticity is no longer constant, however, with agglomeration. Suppose $\omega_d > 0$ and there is a decrease in the tax. This has the immediate effect of raising capital demanded by firms; since capital and labor are complements in production, labor demanded must also rise. This increase in labor demand, as above, has the effect of raising wages. In the numerator of (2.22), the term $\omega_d(1-\eta_i)$ shows an additional impact on wages through the agglomeration effect of an increase in the capital stock. Wages are also driven up, in proportion to η_i, by the increase in labor demand. This effect, shown in the denominator, however, is moderated by the formal sector labor supply elasticity ζ. If the labor supply elasticity is higher, the denominator will be smaller, raising the magnitude of γ^W_{idt}. More labor can be brought in for a smaller increase in wages.

Properties of γ^K_{idt} To derive γ^K_{idt}, we simply take logs of the profit maximization aggregate condition (2.3) having substituted in the tax for the price of capital, and take the derivative with respect to with respect to $\ln(1+\tau_{idt})$. Here we apply the chain rule, recognizing that L_{idt} is an implicit function of $\ln(1+\tau_{idt})$ through the wage rate defined by the spatial equilibrium.[12] This yields

$$\gamma^K_{idt} = \gamma^W_{idt} + \gamma^W_{idt} \cdot \zeta(F_{idt}) - 1 \tag{2.23}$$

Observe that even if there are no economies of scale, and γ^W_{idt} is constant, this elasticity is still non-linear in F_{idt} through the labor supply elasticity. This is a result of the substitution between capital and labor in the cost function. If the price of capital goes up, the capital labor ratio must adjust so that it is in constant proportion to the ratio of wages to the price of capital; the extent to which capital adjusts will be determined by how quickly wages adjust as the capital bill changes.

2.6.4 Efficiency of the Spatial Equilibrium

We can now ask whether the spatial equilibrium is welfare maximizing by evaluating the identity for the optimal policy rule (2.17) at $\boldsymbol{\tau_{idt}} = \mathbf{0}$. Note that here, there is no change in the aggregate capital stock, and so the term in the numerator of $\xi(\boldsymbol{\tau_{idt}})$ is given by $\sum_d^I \frac{K_{idt}}{\bar{K}_t} \frac{\partial \ln(K_{idt})}{\partial \ln(R_{idt})} = \sum_d^I \frac{R_{idt}}{\bar{K}_t} \frac{\partial K_{idt}}{\partial R_{idt}} = \frac{R_t}{\bar{K}_t} \sum_d^I \frac{\partial K_{idt}}{\partial R_t} = 0$, implying that $\xi(\boldsymbol{\tau_{idt}}) = 0$. Substituting this result and the elasticities (2.22) and (2.23) into (2.17) yields

$$\tau^\star_{idt} = \frac{1 + \frac{\eta_i}{1-\eta_i} \frac{1+\eta_i+\omega_d(1-\eta_i)}{\omega_d\left(1-\eta_i+\iota\left(\frac{1-F_{idt}}{F_{idt}}\right)\right)-\eta_i}}{\iota\left(\frac{1-F_{idt}}{F_{idt}}\right)} \forall\, i,d,t. \tag{2.24}$$

Evaluating this at $\tau^\star_{idt} = 0$ yields a unique value of F_{idt} that is a function only of ι, ω_d, and η_i:

$$F_{idt} = \frac{(1-\eta_i)\iota\omega_d}{2\eta_i - \omega_d + 3\eta_i\omega_d - 2\eta_i^2\omega_d + \iota\omega_d - \eta_i\iota\omega_d} \forall\, i,d,t. \tag{2.25}$$

This condition clearly does not satisfy the equilibrium condition (2.9) in the presence of heterogeneous N_{idt} and $\tilde{A}_{idt}$. We have shown that the spatial equilibrium is not welfare maximizing. There are three reasons for the inefficiency of the equilibrium.

The first source of inefficiency is the presence multiple equilibria. Regions stuck in the poverty trap require a "big push", of $\tau_{idt} = -1$ that lowers the cost of capital to zero temporarily to push them into the high wage equilibrium. Having gotten past the big push, however, there are still two additional source of inefficiency, even when each region has positive formal sector development.

[12] Here we have assumed that there are no general equilibrium effects, and that R_t does not vary with τ_{idt}. Need to add this in; ultimately though it will just be subsumed into the year fixed effect.

The second source of inefficiency within the set of industrialized regions O_t^K are the externalities in the labor and capital markets. Entry of workers and capital into the formal sector makes firms more productive, raising wages. If the agglomeration elasticity ω_d is constant across space, the optimal allocation will equalize employment and investment across space until all differences due to $\tilde{A}_{idt}$ have been eliminated and wages are constant across space. Up to differences in amenities, average utilities have been equalized as well. In fact, adding migration to our model allows us to obtain this allocation. If we ignore differences in amenities across space, and assume that an individual's realization of π is realized only after migration, the endogenous allocation of population N_{idt} to equalize utility will be exactly that which equalizes wages, and by (2.10), F_{idt} across space. This result is analogous to the results of Glaeser and Gottleib (2008) and Moretti and Kline (2013), who find that with a constant agglomeration externality and mobile factors, externalities do not generate a market failure at the national level. A role for policy in our context then, is simply to compensate for the immobility of labor. If there are economies of scale, and individuals cannot move to capital, subsidies are required to bring the capital to them, and those subsidies may be financed by a tax on capital in areas which are already developed, and lowering wages will not force too many people out of the formal sector.

The third source of inefficiency comes from variation in the agglomeration elasticity ω_d. Taking the derivative of (2.25) with respect to ω_d shows that the optimal level of formal sector development in a region is increasing in the agglomeration elasticity. Persistent differences in development across regions may be efficient, but only if the elasticity varies. Note that this could not hold if individuals were allowed to migrate. Migration would equalize utilities across space.

There are thus three justifications for distortions in the capital market to be welfare enhancing. First, if $\omega_d > 0$ in a given region, temporary subsidies can be used as a "big push" to move between equilibria. Second, permanent distortions can be justified to compensate for high costs of migration. Third, even with migration, permanent distortions can be useful to allocate capital to regions with higher agglomeration elasticities. While these justifications all argue for subsidies, which could be financed outside of the model, observe from (2.18) that if the price elasticity of international capital supply $\bar{\xi}$ is high enough, it may beneficial to tax investment in areas with high levels of $\tilde{A}_{idt}$ in order to divert capital to other regions. This discussion appears roughly consistent with the stated objectives of the Indian government, and in particular the stated objectives of the industrial licensing policy itself (Bhagwati, 1970, Marathe, 1986, Guha, 2007).

In sum, we have established that, one, the licensing policies may have a had a strong policy justification, and two, the reform, at the very least, was not welfare enhancing in a Pareto sense, which may explain why it took so long for the consensus around reform to translate into policy.

2.7 Structural Estimates of the Spatial Lewis Model

In this section, we present estimates of the elasticities of equilibrium capital investment and wages to the implicit tax on investment in a region industry. First, we summarize the predictions about these elasticities described above. Second, we summarize the empirical problem of estimating them. Third, we describe the estimation procedure actually used to estimation. Fourth, we present results.

2.7.1 Predictions

The discussion in section 6 allows us to make the following predictions about γ^W_{idt} and γ^K_{idt}. Suppose as in Section 2, we have two regions a and b. In region a, the level of formal sector development F_{iat} is higher for all industry years relative to region b, because of higher exogenous productivity. The model predicts that for each industry i and year t:

1. $|\gamma^W_{iat}|$ = $|\gamma^W_{ibt}|$ if there are no agglomeration economies (e.g. $\omega_a = \omega_b = 0$),
2. $|\gamma^W_{iat}| < |\gamma^W_{ibt}|$ if $\omega_a > 0$,
3. $|\gamma^K_{iat}| < |\gamma^K_{ibt}|$.

Prediction 1, recall, is a result of the fact that without agglomeration economies, capital and labor will adjust when the price of capital increases so that the ratio of labor to capital payments is constant. Proposition 2 comes from the Lewis transition; if there are agglomeration economies, and spillovers from capital investment following a decrease in the price of capital, they will be less pronounced in region a, where it is more expensive to bring in additional labor to complement the new capital. Proposition 3 also comes from the Lewis transition. If the price of capital falls, firms will choose to bring in less additional capital in region a because the marginal laborer there is more expensive.

Thus, with estimates of the average values of these elasticities in high and low development regions, we have an empirical test that can reject both the presence of agglomeration economies, and the Lewis transition phenomenon. The key insight here is that in the Lewis model, though returns may be increasing at low levels of development, they are eventually decreasing due to a fixed population size.

While we do not observe formal sector development F_{idt} directly, our approach will be to proxy for it using baseline 1981 urban share of the population. The approach will be to estimate the two elasticties on split samples of region industry years above and below the median level of urbanization, and to compare them to conduct the tests above.

2.7.2 The Empirical Problem

To test the predictions above, we need only estimates of the average elasticities of wages and capital with respect to the implicit tax in two subsamples of the data. We will denote these estimates $\hat{\gamma}^W$ and $\hat{\gamma}^K$, and define them in the following structural estimating equations:

$$\ln(W_{idt}) = \pi^W_{id} + \rho^W_t + {}^W_t \cdot X_{id} + \hat{\gamma}^W \cdot \ln(1 + \tau_{idt}) + v^W_{idt} \tag{2.26}$$

$$\ln(K_{idt}) = \pi^K_{id} + \rho^K_t + {}^K_t \cdot X_{id} + \hat{\gamma}^K \cdot \ln(1 + \tau_{idt}) + v^K_{idt} \tag{2.27}$$

where X_{id} is a district industry specific baseline variable along which there may be time trends. The the other parameters will be defined in the discussion below.

In estimation of (2.26) and (2.27) we face two distinct challenges. One is omitted variable bias, namely a correlation between $\ln(1 + \tau_{idt})$ and v^W_{idt} and v^K_{idt} respectively. The second is that the implicit tax on capital $\ln(1 + \tau_{idt})$ is itself unobserved in the data. Before describing the actual estimation procedure, we discuss below each challenge in turn and how it will be overcome.

Omitted Variable Bias In the spatial equilibrium defined in the model, W_{idt} and K_{idt} are implicit functions of the tax, $(1 + \tau_{idt})$, the national cost of capital R_t, and the region industry's exogenous productivity from natural advantages, $\tilde{A}_{idt}$. The key identification challenge in the equations above is then unobserved correlation between the measured tax $(1 + \tau_{idt})$ an unobserved exogenous productivity. Given that government policy explicitly designed the schedule of taxes and subsidies as a way to correct natural productivity advantages, this correlation is of first order concern. In addition, we are concerned about correlation between $(1+\tau_{idt})$ and R_t through general equilibrium effects.

Equations (2.26) and (2.27) include a number of controls to address these concerns. The district industry fixed effects, π_{id}^W and π_{id}^K, control for time invariant differences in productivity across district industries. The year dummies, ρ_t^W and ρ_t^K, control for national productivity trends affecting all industries equally. These trends also control for general equilibrium effects of the tax on the national cost of capital R_t. Finally, the terms ${}_t^K$ and ${}_t^W$ allow for time trends in unobserved productivity that vary with baseline characteristics of the industry region X_{id}. We will discuss the choice of X_{id} subsequently.

Any additional variation in productivity, $\tilde{A}_{idt}$, driving the wage and capital stock will be picked up by the unobserved error terms v_{idt}^W and v_{idt}^K. There is a real concern that there is a correlation between $\ln(1+\tau_{idt})$ and v_{idt}, because across time, local government officials may have adjusted the implicit tax on capital in response to innovations in productivity, for instance lowering the difficulty of obtaining a license in a city in response to an adverse productivity shock.

We will make use of the Indian government's reform of industrial licenses to overcome these concerns. As described in Section 3, these delicensing reforms were driven by unexpected leadership changes in government and plausibly unrelated to the unobserved productivity terms v_{idt}^W and v_{idt}^K at the level of a particular district. Specifically, we will estimate "first-stage" parameters that give the effect of delicensing on $\ln(1+\tau_{idt})$, and then use these in combination with the effects of delicensing on wages and capital to derive the desired elasticities. While the delicensing reform created variation only at the industry year level, we will increase statistical power by using the heterogeneous response to delicensing according to baseline characteristics of the region industry create variation in the delicensing response at the region industry year level.

Unobserved Implicit Taxes The second challenge is that the term $\ln(1+\tau_{idt})$ is itself unobserved. Our approach will be to assume that, by observing the responses of capital stock, employment and the wage bill, we can infer what the changes in the implicit tax must have been. In this sense, we take the interpretation of licensing policy given in Section 3 quite literally. This interpretation of the reform is identical to the one used by Hsieh and Klenow (2009) in their study of the reforms. Any effects of delicensing on wages or capital will interpreted as effects driven by the behavioral response of firms to a change in implicit price of capital. Note that for identification, we need not assume that delicensing did not affect the level of productivity in the region; indeed, it is precisely through the agglomeration effects of capital investment and hiring induced by delicensing that the wage rate may change.

We begin by writing the ideal "first-stage" equations, which we would estimate were the implict tax observed. We will proceed to derive this from the parameters of equations which are estimable directly from the data. This equation is:

$$\ln(1+\tau_{idt}) = \alpha^{\tau}_{id} + \beta^{\tau}_{t} + \lambda^{\tau}_{t} \cdot X_{id} + D_{it} \cdot [\delta^{\tau} + \sigma^{\tau} \cdot X_{id}] + \varepsilon^{\tau}_{idt} \tag{2.28}$$

where D_{it} is a dummy for whether industry i is delicensed in year t, and X_{id} is a baseline covariate that allows for heterogeneous time trends, λ^{τ}_{t}, and heterogeneous effects of delicensing, σ^{τ}. The average effect of delicensing is given by δ^{τ}. The term α^{τ}_{id} is a district industry fixed effect, β^{τ}_{t} year fixed effects, and ε^{τ}_{idt} is an i.i.d. error term.

Though we do not observe $\ln(1+\tau_{idt})$ directly, we will assume that it takes a particular structure given by the model. In this sense we are following Chari et. al. (2007) and Hsieh and Klenow (2009) and who infer implicit taxes as "wedges" between the observed ratio of payments to capital and labor, and the optimal ratio implied by profit maximization in a market where all districts face the same lending rate. Specifically, combining the profit maximization equation (2.3) and the district specific price of capital in the presence of the tax given by (2.13) yields

$$(1+\tau_{idt}) = \frac{W_{idt} L_{idt}}{R_t K_{idt}} \left(\frac{1-\eta_i}{\eta_i} \right) \tag{2.29}$$

Taking the log of (2.29) and substituting it into (2.28) yields,

$$\begin{aligned} \ln(W_{idt}) + \ln(L_{idt}) - \ln(K_{idt}) = \left[\alpha^{\tau}_{id} - \ln\left(\frac{1-\eta_i}{\eta_i} \right) \right] + [\beta^{\tau}_{t} + \ln(R_t)] + \\ \lambda^{\tau}_{t} \cdot X_{id} + D_{it} \cdot [\delta^{\tau} + \sigma^{\tau} \cdot X_{id}] + \varepsilon^{\tau}_{idt} \end{aligned} \tag{2.30}$$

which makes clear that the first stage relationship of interest can be inferred purely from effect of delicensing on wages, labor, and capital, with district industry fixed effects and year effects to subsume the factor shares and national cost of capital respectively.

2.7.3 Estimation Procedure

We will use three variables at the industry district year observed in the ASI data for estimation, the wage bill ($W_{idt}L_{idt}$), labor employed in terms of person days (L_{idt}), and the capital stock (K_{idt}). With these variables we will estimate simultaneously the following three equations:

$$\ln(W_{idt}L_{idt}) = \alpha_{id}^{WL} + \beta_t^{WL} + \lambda_t^{WL} \cdot X_{id} + D_{it} \cdot \left[\delta^{WL} + \sigma^{WL} \cdot X_{id}\right] + \varepsilon_{idt}^{WL} \tag{2.31}$$

$$\ln(L_{idt}) = \alpha_{id}^{L} + \beta_t^{L} + \lambda_t^{L} \cdot X_{id} + D_{it} \cdot \left[\delta^{L} + \sigma^{L} \cdot X_{id}\right] + \varepsilon_{idt}^{L} \tag{2.32}$$

$$\ln(K_{idt}) = \alpha_{id}^{K} + \beta_t^{K} + \lambda_t^{K} \cdot X_{id} + D_{it} \cdot \left[\delta^{K} + \sigma^{K} \cdot X_{id}\right] + \varepsilon_{idt}^{K} \tag{2.33}$$

Though the data do not explicitly report wage rates, by substituting the labor equation (2.32) into the wage bill equation (2.31) we can also define the direct effect of delicensing on wages themselves. From this substitution we have,

$$\ln(W_{idt}) = \left[\alpha_{id}^{WL} - \alpha_{id}^{L}\right] + \left[\beta_t^{WL} - \beta_t^{L}\right] + [\lambda_t^{WL} - \lambda_t^{L}] \cdot X_{id} + \tag{2.34}$$

$$D_{it} \cdot \left[(\delta^{WL} - \delta^{L}) + (\sigma^{WL} - \sigma^{L}) \cdot X_{id}\right] + \varepsilon_{idt}^{WL} - \varepsilon_{idt}^{L} \tag{2.35}$$

and can define

$$\delta^W \equiv \delta^{WL} - \delta^L$$
$$\sigma^W \equiv \sigma^{WL} - \sigma^L,$$

which are the direct and heterogeneous effects of delicensing on wages.

We are now ready to derive the structural parameters from the parameters which are directly estimable. Substituting the estimating equations (2.31) and (2.33) into (2.30) shows that the first stage parameters indicating the effect of delicensing on the implict tax are given by

$$\delta^\tau = \delta^{WL} - \delta^K$$
$$\sigma^\tau = \sigma^{WL} - \sigma^K$$

These are the desired parameters in the "first-stage" equation (2.28); the effect of delicensing on $\ln(1 + \tau_{idt})$ is inferred simply by the difference of the effect on the wage bill and on capital investment.

With these parameters in hand, we substitute the first stage equation (2.28) into the structural equations (2.27) and (2.26) respectively. This yields,

$$\ln(W_{idt}) = \left[\pi^W_{id} + \alpha^\tau_{id} \cdot \hat{\gamma}^W\right] + \left[\rho^W_t + \beta^\tau_t \cdot \hat{\gamma}^W\right] + \left[{}^W_t + \lambda^\tau_t \cdot \hat{\gamma}^W\right] \cdot X_{id} +$$
$$D_{it} \cdot \hat{\gamma}^W \cdot [\delta^\tau + \sigma^\tau \cdot X_{id}] + \varepsilon^\tau_{idt} + v^W_{idt}\hat{\gamma}^W$$

and

$$\ln(K_{idt}) = \left[\pi^K_{id} + \alpha^\tau_{id} \cdot \hat{\gamma}^K\right] + \left[\rho^K_t + \beta^\tau_t \cdot \hat{\gamma}^K\right] + \left[{}^K_t + \lambda^\tau_t \cdot \hat{\gamma}^K\right] \cdot X_{id} +$$
$$D_{it} \cdot \hat{\gamma}^K \cdot [\delta^\tau + \sigma^\tau \cdot X_{id}] + \varepsilon^\tau_{idt} + v^K_{idt}\hat{\gamma}^K$$

A comparison of these equations and the wage and capital estimating equations (2.35) and (2.33) yields the following identities relating the structural parameters to the parameters estimated in (2.35), (2.32) and (2.33):

$$\delta^W = \delta^\tau \hat{\gamma}^W \qquad \sigma^W = \sigma^\tau \hat{\gamma}^W \tag{2.36}$$

and

$$\delta^K = \delta^\tau \hat{\gamma}^K \qquad \sigma^K = \sigma^\tau \hat{\gamma}^K \tag{2.37}$$

Using the definitions of δ^W, σ^W, δ^τ and σ^τ from above yields the following estimators

$$\hat{\gamma}^W_1 = \frac{\delta^{WL} - \delta^L}{\delta^{WL} - \delta^K} \quad \hat{\gamma}^W_2 = \frac{\sigma^{WL} - \sigma^L}{\sigma^{WL} - \sigma^K} \tag{2.38}$$

and

$$\hat{\gamma}^K_1 = \frac{\delta^K}{\delta^{WL} - \delta^K} \quad \hat{\gamma}^K_2 = \frac{\sigma^K}{\sigma^{WL} - \sigma^K} \tag{2.39}$$

We have thus shown that we can identify a first order linear approximation of $\hat{\gamma}^W$ and $\hat{\gamma}^K$ using purely the effect of delicensing on the observed wage bill, labor employed and capital stock. Further, with heterogeneous effect of delicensing with a covariate X_{id}, the model is over identified.

Our estimation routine will estimate these parameters in three steps. First we will estimate (2.31), (2.32) and (2.33) simultaneously. Second, we will use the delta method to calculate the values of the four estimators for the structural parameters defined in (2.38) and (2.39) and their variance covariance matrix. Third, we will use Chamberlain's minimum distance estimator to estimate a single value for each γ_W and γ_K and their standard errors. We will duplicate this procedure on above and below median urbanization region industries to test the predictions stated at the beginning of the section.

Choosing X_{id} for increased power The final exercise is to choose an appropriate variable for X_{id} in order to increase power and induce heterogeneous effects of delicensing across regions. One option would be to use baseline district characteristics, as in the reduced form evidence. These variables would add limited power however because they force all industries to respond equally to delicensing in the same district. In addition, as we saw in Section 5, the heterogeneity of effects in log terms along these variables was highly non-linear, making these variables inappropriate for the log linear structural equations such as the ones specified above.

Instead we construct a variable that predicts, using baseline characteristics, the predisposition of a region industry to respond to delicensing. If we regard the policy shock as one that would reduce implicit taxes, the natural choice of X_{id} would then be the average implicit tax observed in baseline, which we can denote $\ln(1 + \bar{\tau}_{id})$.

While this implicit tax itself is unobserved, we can proxy for it using equation (2.29) and our data on the capital stock and wage bill if only we have an estimate of the national cost of capital R_t, and the industry specific cost shares η_i. Two observations are required here. One, for our purposes it is not important here to generate a precise estimate of the implicit tax, but rather simply to generate a variable that is correlated with it. Two, the implicit tax calculated using (2.29) will show only the *relative* tax on capital relative any implicit taxes that may exist on labor. If hiring labor was subsidized in a region, for instance, in ways that do not show up in the wage bill, or if there are restrictions on firing workers, causing labor demanded to be artificially high, this wil show up as a higher implicit tax on capital.

To calculate this average baseline tax, For R_t,we use the World Bank reported national prime lending rate. Under the assumption of profit maximization and constant returns, η_i equals the labor share of income in each district. We estimate η_i using the average of this payment ratio across districts

$$\eta_i = E_i \left[\frac{W_{itd} L_{itd}}{Y_{idt}} \right] \tag{2.40}$$

where the expectation operator is across district years.[13] With these estimates and the data, we thus calculate an average $\ln(1+\bar{\tau}_{id})$ for each industry district in years before delicensing.

Our estimating equations become

$$\ln(W_{idt}L_{idt}) = \alpha_{id}^{WL} + \beta_t^{WL} + \lambda_t^{WL} \cdot \ln(1+\bar{\tau}_{id}) + D_{it} \cdot \left[\delta^{WL} + \sigma^{WL} \cdot \ln(1+\bar{\tau}_{id})\right] + \varepsilon_{idt}^{WL} \tag{2.41}$$

$$\ln(L_{idt}) = \alpha_{id}^{L} + \beta_t^{L} + \lambda_t^{L} \cdot \ln(1+\bar{\tau}_{id}) + D_{it} \cdot \left[\delta^{L} + \sigma^{L} \cdot \ln(1+\bar{\tau}_{id})\right] + \varepsilon_{idt}^{L} \tag{2.42}$$

$$\ln(K_{idt}) = \alpha_{id}^{K} + \beta_t^{K} + \lambda_t^{K} \cdot \ln(1+\bar{\tau}_{id}) + D_{it} \cdot \left[\delta^{K} + \sigma^{K} \cdot \ln(1+\bar{\tau}_{id})\right] + \varepsilon_{idt}^{K} \tag{2.43}$$

The main concern with the use of this proxy is that our estimated implicit taxes may have a tendency to mean revert over time. If this were the case, places with high measured taxes may lower their wage bill, or raise capital investment over time so that the long run implicit tax is reduced. These concerns, however, should be allayed by observing that the parameters λ_t^{WL}, λ_t^{L},λ_t^{K} will capture any time trends in $\ln(1+\bar{\tau}_{id})$. These controls ensure that heterogeneous effects in delicensing due to $\ln(1+\bar{\tau}_{id})$ are not due to mean reversion.

2.7.4 Results

Estimates of $\ln(1+\bar{\tau}_{id})$**.** Our first exercise is to describe the calculated values of $\ln(1+\bar{\tau}_{id})$ that will be used in estimation. This exercise also provides a basic reality check for our model. If implicit taxes are not high in urban areas, for instance, our reduced form estimates in Section 5 would suggest our model is badly mis-specified. Figure 2.4 shows the distribution of this variable. The mean industry region has a positive implicit tax of approximately 0.81; that is to say, if the production function is as specified in our calculation of $\ln(1+\bar{\tau}_{id})$, the marginal product of capital in the average region is 81% higher than the cost, suggesting substantial under-investment.

Table 2.4 shows that the implicit taxes, controlling for industry fixed effects, are also correlated with many regional characteristics, as expected. Here, regional characteristics have been standardized to Z-scores so the reported coefficients can be interpreted as the percentage point change in the mark up of the marginal product of capital over its cost associated with a 1 standard deviation change in the characteristic. For instance, in column 1, a one standard deviation increase in

[13] Note that this result does not depend on the assumption of constant returns. Profit maximization delivers an identical equation to (2.3) using a production function of the form $Y_{idt} = A_{idt}L_{idt}^{\eta_i\delta}K_{idt}^{(1-\eta_i)\delta}$ with $0 < \delta < 1$.

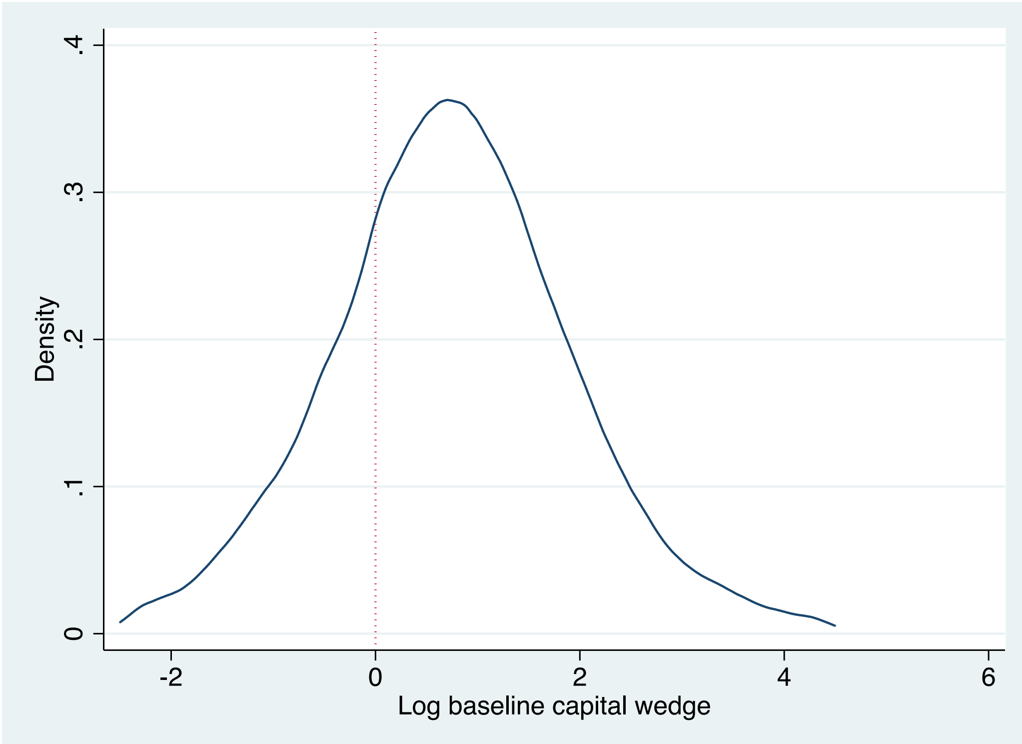

Figure 2.4: *Distribution of estimated* $\ln(1+\bar{\tau}_{id})$ *over all region industries, truncated at the 1st and 99th percentiles.*

distance to the coast is associated with at 12.3 percentage point decrease in the mark up, indicating that industries closer to the coast face higher implicit taxes on investment. We find no significant effect of the terrain ruggedness index of Nunn and Puga (2012), or of communal riots per capita in columns 2 and 3 respectively. Surprisingly, areas with high credit market development, as measured by 1980 non-agricultural credit outlay per capita face higher distortions—9.6 percentage points—per standard deviation, suggesting that scale in capital markets is not sufficient to reduce distortions in investment demand. As expected, areas with high primary school attainment and high urbanization have significantly higher distortions. Finally, backwards areas, which are targeted by the government for investment, have lower distortions, as do areas receiving greater political support for the Indian National Congress in Parliamentary elections. This finding suggests that capital market distoritions may respond to electoral incentives. We find no significant effect of government share of employment on the implicit tax potentially reflecting the fact that state owned firms, just as were private ones, were generally not differentially subject to investment taxes or subsidies.

Table 2.4: *Regional correlates of baseline wedges across industry regions.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	$\ln(1+\bar{\tau}_{id})$	$\ln(1+\bar{\tau}_{id})$	$\ln(1+\bar{\tau}_{id})$	$\ln(1+\bar{\tau}_{id})$	$\ln(1+\bar{\tau}_{id})$	$\ln(1+\bar{\tau}_{id})$	$\ln(1+\bar{\tau}_{id})$	$\ln(1+\bar{\tau}_{id})$	$\ln(1+\bar{\tau}_{id})$
Ln(Distance to coast)	-0.123***								
	(0.017)								
Terrain ruggedness index		-0.026							
		(0.017)							
Ln(Annual no. of riots per 1000 people)			0.027						
			(0.017)						
Ln(Non-agricultural credit outlay per capita)				0.096***					
				(0.013)					
Primary school attainment					0.139***				
					(0.018)				
Urban share of population						0.100***			
						(0.015)			
Backwards Area							-0.138***		
							(0.031)		
Government share of employment								-0.016	
								(0.016)	
Indian National Congress parliamentary vote share									-0.072***
									(0.017)
R^2	0.203	0.194	0.194	0.200	0.206	0.200	0.197	0.194	0.197
Number of observations	5,781	5,781	5,781	5,781	5,781	5,781	5,781	5,781	5,781
Industry fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses. Dependent variable is the mean wedge in years prior to delicensing. All independent variables except the backwards area dummy have been standardized as Z-scores. Distance to coast is the Euclidean kilometer distance measured from the region centroid. Terrain ruggedness index is calculated using the data and procedure of Nunn and Puga (2012). Annual number of riots is the average of the annual number of riots reported by the Ministry of Home Affairs between 1970-1980, divided by 1971 population. Credit outlay per capita is 1980 non-agricultural credit outlay reported by the Reserve Bank of India in 1980, divided by 1981 population. Primary educational attainment is the share of individuals over age 15 having completed primary education, measured in the 1981 census. Urban share of the population is measured in the 1981 census. Backwards area is a dummy variable indicating whether at least one distirct in the region was eligible for the Central Investment Subsidy scheme in 1983, as reported by Mohan (2005). Government share of employment is the average share of employment in the ASI in government owned establishments between 1980-1983. INC Parliamentary vote share is the share of total votes going to the Indian National Congress party in the 1980 national Parliamentary elections *** p<0.01, ** p<0.05, * p<0.1

Table 2.5: *Reduced form estimates of delicensing's effect in logs, with heterogeneity in* $\ln(1+\bar{\tau}_{id})$.

VARIABLES	(1) $\ln(W_{idt}L_{idt})$	(2) $\ln(W_{idt}L_{idt})$	(3) $\ln(L_{idt})$	(4) $\ln(L_{idt})$	(5) $\ln(K_{idt})$	(6) $\ln(K_{idt})$
Delicensed	0.046	0.068	0.027	0.083**	0.059	-0.162***
	(0.036)	(0.046)	(0.032)	(0.041)	(0.044)	(0.055)
Delicensed $\times$ $\ln(1+\bar{\tau}_{id})$		-0.041		-0.075**		0.292***
		(0.037)		(0.034)		(0.046)
R^2	0.785	0.786	0.765	0.765	0.750	0.754
Number of observations	37,106	37,106	37,106	37,106	37,106	37,106
Industry $\times$ region fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Year $\times$ $\ln(1+\bar{\tau}_{id})$ effects	NO	YES	NO	YES	NO	YES

Notes: Standard errors in parentheses are robust to heteroskedasticity and allow for arbitrary correlation at the industry region level. Real wagebill ($W_{idt}L_{idt}$) is deflated by the industry price index. Person years (L_{idt}) are measured as person days divided by 365. Real capital stock (K_{idt}) is deflated by the industry capital price index. *** p<0.01, ** p<0.05, * p<0.1

Structural Estimating Equations. Table 2.5 presents estimates of the structural estimating equations (2.41), (2.42) and (2.43) in columns 2, 4 and 6 respectively. In columns 1, 3, and 5, we see that delicensing has no significant average effect on the variables without including the heterogeneous effect by baseline implicit tax. This confirms our intutition that the policy change itself would not be enough to identify the effect. Given that the much of the effect of delicensing shown in Section 5 was to reallocate factors and not increase their level overall, this result is not surprising.

With heterogeneity, we find results as expected. Column 6 shows that regions with greater baseline implicit taxes had greater increases in capital. Column 4 shows that they reduced their labor demanded. This could be because delicensing also reduced distortions in the labor market causing labor demanded before to be artificially high. It is also consistent with a wage increase, and capital being used to substitute for labor. That the effect in column 2 on wage bill is insignificant and lower in absolute value than the effect on person wages suggests that wages indeed went up in these areas. This story is consistent with agglomeration economies being driven by an increase in the capital stock.

Estimates of $\hat{\gamma}^K$ and $\hat{\gamma}^W$. Estimates of the sufficient policy elasticties are presented in Table 2.6, both for the full sample, and the sample split by below and above median baseline urbanization

Table 2.6: *Minimum distance estimates of $\hat{\gamma}_W$ and $\hat{\gamma}_K$, with heterogeneity by urbanization.*

ELASTICITY	(1) Full sample	(2) Below median urbanization	(3) Above median urbanization
$\hat{\gamma}_W$	-0.106***	-0.146***	-0.083**
	(0.034)	(0.052)	(0.046)
$\hat{\gamma}_K$	-0.892***	-0.988***	-0.817***
	(0.102)	(0.157)	(0.132)
Number of observations	37,106	18,622	18,484

Notes: Standard errors shown in parenthesis calculated using Chamberlian's minimum distnace estimator and account for heteroskedasticity and arbitrary correlation of reduced form errors within region industries. Column 1 shows estimates calculated from the same sample as in Table 5. Column 2 shows estimates calculated using region industries with below median urbanization; Column 3 shows estimates calculated using region industries with above median urbanization. Both elasticities in above median urbanization regions are significantly lower than in below median regions, with T-statistics equal to -27.41 for $\hat{\gamma}_W$, and -43.32 for $\hat{\gamma}_K$. *** p<0.01, ** p<0.05, * p<0.1

rates. Column 1 presents the estimates on the full sample. Here the signs are negative, as expected and substantial in magnitude. The estimate of $\hat{\gamma}^W = -0.106$ (s.e. = 0.034) indicates that when the marginal product of capital in the average region industry is double the price of capital, wages are reduced by 10.6%. The estimate of $\hat{\gamma}^K = -0.892$ (s.e. = 0.102) is statistically indistinguishable from constant returns to scale, in which $\gamma^K_{idt} = 1$. Comparing a region in which the markup of the marginal product of capital over its price is 100% to a region in which they are equal, the region with the markup will have 89.2% lower capital stock; capital and the marginal product move almost one-to-one with each other.

Comparing the estimates in columns 2 and 3 allow us to test the predictions of the Lewis model described above. Here we estimate that in areas with low urbanization, a proxy for low F_{idt}, $\hat{\gamma}^W = -0.146$ (s.e. = 0.052). In areas with high urbanization the elasticity is almost half the size, at $\hat{\gamma}^W = -0.083$ (s.e. = 0.046); the T-statistic for the significance of the difference is -27.41. This result provides strong evidence for the Lewis transition, and for the presence of agglomeration economies. In urbanized areas, where wages are higher, reducing the cost of capital has a lower effect on subsequent wage growth than in an region that is not urbanized, and workers can be pulled cheaply from the informal sector.

We find a similar result with respect to the capital elasticity $\hat{\gamma}^K$. In more urbanized areas it is lower in absolute value than in less urbanized areas, suggesting that returns to scale may be ultimately decreasing in the most urbanized areas, though we lack the statistical power to test this prediction directly.

We have thus confirmed the key predictions of the spatial Lewis model, and found strong evidence of agglomeration economies.

2.8 Counterfactual Policy Simulations

In this section we use the estimated elasticities to conduct three counter factual policy simulations, which highlight the heterogeneous welfare impacts of policies designed to reallocate capital across space. The results of the three simulations are displayed in Table 2.7.

Counterfactual 1: Reduce capital wedge to zero. Here we do an extreme counterfactual, which is to reduce the implicit taxes on capital to zero in all regions. We can think of this as achieving the competitive spatial equilibrium benchmark provided by the model in Section 2. The average baseline implicit tax $\ln(1 + \bar{\tau}_{id})$, calculated using the methodology described above, is positive on average at 0.818. In below median urbanization regions it is still positive on average, at 0.755, though at 10 percentage points less than in above median urbanization areas. The fact that implicit taxes themselves are not on average negative in rural areas reflects the fact that other policies in the economy may also be taxing investment, beyond those that are place-based.

In column 1, we estimate the effect on wages of reducing all distoritions to zero in the full sample to be 8.7%. The capital stock would also increase by 73%. In column 2, we find that even though average distortions in less urbanized areas are smaller, reducing them would have a disporortiationately large effect on wages, relative to the same reduction in highly urbanized areas. This suggests that, in the presence of economies of scale that are ultimately falling due to the Lewis transition, reducing constaints on investment may have disproportionately large effects on wages in rural areas where labor can be pulled cheaply from the formal sector.

Counterfactual 2: Equalize wedges to that of the other sample. Here we do a more realistic counterfactual, in which we equalize the implicit tax on investment between samples. First, in

Table 2.7: *Counterfactual simulations using point estimates of $\hat{\gamma}_W$ and $\hat{\gamma}_K$.*

	(1) Full sample	(2) Below median urbanization	(3) Above median urbanization
Counterfactual 1: Reduce capital wedge to zero			
Mean baseline wedge	0.818	0.755	0.852
Change in wages	8.7%	11.0%	7.1%
Change in capital stock	73.0%	74.6%	69.6%
Counterfactual 2: Equalize wedges to that of other sample			
Change in wages		-1.42%	0.81%
Change in capital stock		-9.58%	7.92%
Counterfactual 3: Move government owned capital stock			
γ_W / γ_K	0.118	0.148	0.102
Change in wages after moving capital from above median to below		11.23%	-2.60%
Change in wages after moving capital from below median to above		-3.53%	0.83%

Notes: Counterfactual 1 reduces the wedge from the level reported to zero. Counterfactual 2 equalizes wedges. In column 2, wedges in below median urbanization regions are raised to the average baseline level in above median regions. In column 3, wedges in above median urbanization regions are lowered to those in below median regions. Counterfacutal 3 simulates moving the government owned capital stock between samples. In below median urbanization regions government owned capital stock is 23.9%, in above median urbanization areas it is 25.6%. The government owned capital stock in above median urbanization areas however is 76% of the capital stock in below median areas; the stock in below median areas is 8.2% of that in above median areas.

column 2, we ask what would happen if we raised the implict tax in below median urbanization areas to the level it is in above median urbanization areas. This would reduce wages by 1.42%. In column 3, reducing distortions in above median urbanization areas to that of low urbanization areas would increase wages by only 0.81%. We can think of this as a reasonable benchmark for what might actually be achievable, given other implicit taxes in the economy. Again, we see that movements in the distortions have disproportionately large effects in rural areas. Reducing distortions in urban areas has a small effect relative to raising them in rural areas.

Counterfactual 3: Move government owned capital stock. Another way to conceive of government policy is not that it affects the price of capital investment in a region, but that it physically moves capital around, by controlling, for instance, the investment decisions of state-owned enterprises. In the ASI data, in below median urbanization regions, government owned capital is 23.9% of the total capital stock, and in above median urbanization areas it is slightly higher at 25.6%. A final counterfactual simulation is to reallocate this capital from high urbanization regions to low urbanization regions and vis-a-versa.

To do this, we will need to derive an elasticity of the wage rate with respect to the capital stock. Since, in the model, the wage rate is a function of the capital stock entirely though the implicit tax's effect on the capital stock, application of the chain rule shows that

$$\frac{\partial \ln(W_{idt})}{\partial \ln(K_{idt})} = \frac{\gamma^W_{idt}}{\gamma^K_{idt}}. \tag{2.44}$$

As shown in Table 2.7, the estimates imply that overall, this elasticity is 0.148 in below median urbanization areas, and 0.102 in above median urbanization areas, suggesting that government investment indeed has greater effects on wages rates in rural areas than it does in urban ones.

In our counterfactuals, moving all the (average) government owned capital from above median to below would induce an 11.23% increase in wages with only a 2.6% decrease in wages in urban areas. Seen another way, moving all the (average) government owned capital from below median areas to above median ones would increase wages in urban areas by 0.83%, but reduce wages in the below median areas by 3.53%.

2.9 Concluding Remarks

This paper has developed a theoretical framework for the analysis of place based policies in a developing country context, and analyzed a particularly salient such policy abolished by the Indian government in the late 20th century. The reduced from results suggest that the reform created winners and losers, reducing the formal sector wage bill in rural regions and raising it in urban ones. Given constraints on migration in India, the model suggests these effects were first order for welfare, and disproportionately so, with welfare (wage bill) falling by 37% in the bottom quartile of urbanized areas, and rising by only 11% in the top quartile of urbanized areas.

The spatial Lewis model proposed gives context for these results. Due to agglomeration economies, and relatively abundant labor in rural areas, a small decrease in the price of capital in the area induced by delicensing may have had large positive effects on wages, the wage bill, and welfare. Reforming the policy, and allowing the price of capital in this region to again rise caused capital to reallocated to urban areas. However, since the marginal laborer is more expensive in urban areas, an additional unit of capital will pull in less labor, and the gains from economies of scale were less than in the rural area.

This results suggests that policies that distort the allocation of capital across space and cause capital to locate where it may not have in a competitive equilibrium—as did industrial licenses—may not be as costly in the aggregate. If labor is sufficiently expensive in urban areas, the losses from moving capital away may be small. In low and middle income countries like India with inefficient systems to tax and transfer wealth throughout the country, place-based industrial policy may have been useful "second best" policy for redistributing income, with limited costs. This point is illustrated by three counter factual policy exercises.

This paper has focused on place-based policy on the intensive margin, allocating capital to and from places which already have some of it. Though there was some evidence that the licensing reform caused new industries to emerge in urban areas, and close down in rural ones, the analysis of the model was limited to policy affecting industrialization on the intensive margin. Questions of how one really designs policy to establish industrialization from nothing—the questions at the heart of the discussion of the "big push"—are exciting ones for future research.

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Chapter 3

Interlinked Transactions and Pass-through: Experimental Evidence from Sierra Leone[1]

3.1 Introduction

Rural areas of developing economies often lack formal financial institutions. In their absence, agents in the rural supply chain have emerged as a substitute source of credit for producers and households. For instance, an intermediary buying agricultural produce for a wholesaler may provide payment in advance to the farmer for output, allowing the farmer to smooth consumption. A long tradition in development economics has observed that relationships such as these lead to transactions that are *interlinked*: the price at which output is purchased is determined jointly with the terms of the credit contract, and vice versa (e.g. Bardhan, 1980, Braverman and Stiglitz, 1982, Bell, 1988, Grosh, 1994, Deb and Suri, 2012). More generally, firm-to-firm credit is more prominent for small firms and when financial institutions are weak (e.g. Petersen and Rajan, 1997; Fisman and Love, 2003).[2]

[1] Co-authored with Lorenzo Casaburi

[2] In the United States, small businesses rely on trade credit for about 60% of their external finance (Mach and Wolken, 2006).

As a consequence, product market conditions may affect the supply of credit. If the wholesale value of a farmer's produce for the intermediary rises, so might the credit supplied to the farmer. In this paper, we argue that the presence of such interlinkages affects how value is passed through the supply chain from buyers to producers. Interlinkages may provide an important explanation, particularly in remote areas of developing economies, for why a low rate of price pass-through has been observed, both in aggregated market prices (Atkin and Donaldson, 2013) and in the transactions of individual traders (Fafchamps and Hill, 2008; Mitra et al., 2013). These findings have been interpreted as evidence of price rigidity, imperfect competition, or large distribution costs, all of which have the implication that in the presence of low price pass-through, incentives for producers are distorted (for a review see Burstein and Gopinath, 2012). Our work suggests interlinkages are additional mechanism that may generate low price pass-through, but with a different implication for producers and the efficiency of the supply chain. If buyers pass through some of a good's value in credit that is later repaid in lower prices, there may be in fact more transmission of incentives than is observed if one only looks at transaction prices, and producer welfare may be higher. This observation enhances our understanding of how producer investment decisions may respond to policies that affect border prices, such as trade liberalization and export subsidies.

Our paper makes three contributions. First, we discuss the results of a randomized experiment in a set of agricultural markets designed to elucidate the separate margins through which value is passed through by individual traders. The experiment is set in the cocoa industry of Sierra Leone, West Africa, where interlinked transactions such as the one described above are common. Survey evidence suggests that interlinkages are common across Africa. For instance, a report on East and Southern Africa by IFAD (2003, pg. ii) observes "credit under contract farming arrangements is one of the major (indeed, often, the only) forms of access to production finance among smallholders."[3] We pay a treatment group of intermediaries (i.e. farmgate traders) a per-unit bonus for delivering cocoa (above a certain quality standard) to wholesalers. Using detailed data on the prices and credit supplied to farmers, we show that although average pass-through of the bonus is small

[3]Contract farming here is construed broadly, to cover contractual relations between small-scale traders and farmers, as in our setting, as well as relations between farmers and large-scale firms with outgrowing schemes. An overview of these issues is provided by Bijman (2008). Case study evidence from Ghana, India, Madagascar, Mozambique and Nicaragua is given by Barrett et. al. (2012).

in terms of prices, it is substantial in terms of credit outlay. The experiment confirms the two conjectures above: product market conditions faced by the intermediary affect substantially the supply of credit to farmers, and the pass-through of the cocoa's value is masked when one only observes the price at which the cocoa is transacted. To the best of our knowledge, this is the first experiment targeting the propagation of incentives across agents along agricultural value chains.

Second, we develop a simple theoretical model that helps to interpret the results. In our model, changes in the price paid to intermediaries for output shift the share of producers engaged in interlinked transactions as opposed to simply selling on a spot market. In the interlinked transaction, intermediaries pay the producer in advance for the good, a form of forward credit that the producers use to smooth consumption.[4] This credit is paid back in the form of a lower output price. Therefore, the average rate of price pass-through is determined by the measure of producers who endogenously switch into (or out of) interlinked transactions. In response to an increase in the price they receive from wholesalers, intermediaries may choose to give credit to more producers. For certain parameter values, as these producers move from the spot market to the interlinked transaction, the observed price they receive falls. While farmers benefit from credit provision, this switching between contracts drives down the average rate of price pass-through further than the rate that would obtain if the intermediary were simply an oligopsonist on the spot market. This insight speaks to a recent literature that uses the price pass-through rate as a tool to infer the shares of surplus captured by producers, consumers, and intermediaries in the economy (Fabinger and Weyl, 2013; Atkin and Donaldson, 2013). In the presence of interlinked credit and output markets, a complete welfare analysis needs to include "credit pass-through" as well as the standard price pass-through.

Third, we verify empirically some of the predictions of the model, namely that price and credit pass-through are substitutes. Using correlations in the baseline data, we show that, consistent with the model, credit provision to farmers is higher in markets where proxies for the return to credit are higher. We also show that higher credit provision is negatively correlated with farm-gate prices. Then, using an analysis of heterogeneous treatments effects in the experiment, we show

[4]Intermediaries have also been observed to write contracts that transfer risk from farmers to traders, providing insurance against adverse price and productivity shocks that may affect the farmer. While we acknowledge this is another important margin on which intermediaries may pass through value to farmers, it is not common in our setting, and we leave it to be studied in others.

that those markets that experience a stronger credit response to our bonus show a lower rate of price pass-through. The magnitudes are substantial economically. A village in which the bonus raised the likelihood of credit provision to farmers by the estimated average treatment effect displays price pass-through lower by one-sixth to one-third of perfect pass-through, relative to a village with no effect of the bonus on credit.

As emphasized by Bauer (1954) and Fafchamps (2004), the presence of many layers of intermediation is a defining characteristic of agricultural markets in sub-Saharan Africa. Besides simply transporting goods, intermediaries also provide services such as information, insurance, and, as in our context, credit. While the literature has acknowledged this role, there is little quantitative evidence about how traders' own incentives affect the level of service provision. This paper shows they do, and that the magnitude of this effect can be substantial.

One important difference between ours and other related studies is that while pass-through is generally considered as the response of a price to a change in the world price received by all traders in a the market, our experiment studies pass-through when prices are raised only for some. We provide our model as a simple framework to show how these effects may be relevant for pass-through in the case of a price shock affecting all traders. We then show that the substitutability between credit and prices finds support in the baseline data (i.e. collected before the experiment). In addition, we show that our empirical results are similar when several traders are treated in a given market.

Our work supports a view of intermediaries as service providers, as opposed to a view in which they are simply arbitrageurs.[5] In this sense our work is related to that of Rubenstein and Wolinsky (1987) and Antrás and Costinot (2012), who develop models in which traders provide a service to the market by alleviating search frictions. It is also related to the work on micro-finance by Maitra, Mitra, Mookherjee, Motta, and Visaria (2012) who identify another way in which traders may add value. The authors argue that, given the strength of traders' relationships with clients, traders may have more information about default risk and be able to recommend higher

[5]Given the context, our work also contributes to the extensive literature on agricultural traders in Africa in particular, initiated by Bauer (1954) and Hill (1963) and continued by Fafchamps (2004), Fafchamps, Gabre-Madhin and Minten (2005), Osborne (2005), Fafchamps and Hill (2008) and Casaburi, Glennerster and Suri (2012), among others. More broadly, we also add to the literature studying the nature of inter-firm relationships in developing economies (McMillan and Woodruff, 1999; Banerjee and Duflo, 2000; Macchiavello and Morjaria 2012; Blouin and Macchiavello, 2013).

quality clients to financial institutions.

The paper proceeds as follows. In section 3.2 we describe our experiment and provide summary statistics on traders and the markets used in the study. Section 3.3 discusses our experimental results. In section 3.4 we present a model of pass-through in interlinked transactions and assess its welfare implications. Section 3.5 tests further predictions of the model. Section 3.6 concludes.

3.2 An Experiment in the Sierra Leone Cocoa Industry

In order to elucidate the multiple margins through which intermediaries may pass value to producers in response to a change in their price incentives, we run an experiment in a set of agricultural markets within the cocoa industry of Sierra Leone, West Africa, a setting in which interlinked transactions including credit are common.

3.2.1 The Sierra Leone Cocoa Value Chain

West Africa produces two-thirds of the world cocoa supply. Though given its small size Sierra Leone accounts for only a small share of this total, cocoa is important nationally. The crop comprised 8.6% of exports in 2009, and is by far the country's largest export crop by value, according to the UN COMTRADE database. The industry has also grown tremendously in the last decade, with the value of exports growing ten-fold between 2009 and 2001, when the country's decade long civil war came to an end.

The within-country cocoa trade in Sierra Leone is highly fragmented across many traders, and the supply chain has many links, similar to other agricultural markets in developing economies (for examples in Africa see Fafchamps, Gabre-Madhin, and Minten, 2005, and Osborne, 2005).[6] Farmers sell to traders, who sell to wholesalers in small towns, who in turn sell to exporters in larger towns, who in turn sell to buyers at the port. While the study of pass-through is surely

[6] Sierra Leone's cocoa industry is similar to those in Cameroon, Côte d'Ivoire and Nigeria all of which liberalized during the 1990s and became similarly fragmented (Gilbert, 2009). Though Sierra Leone does have an official marketing board, the organization has been defunct since the war, and the government is responsible for a negligible share of purchases. A potential explanation for the lack of vertical integration in the market in the absence of a strong marketing board are the stringent legal restrictions on the transaction of land discussed in Acemoglu, Reed and Robinson (2013). These, along with weak legal institutions more broadly, would make vertical integration of the supply chain difficult, if not impossible.

relevant at each of these links in the supply chain, we focus on the final link closest to production, and leave the examination of other levels for future research. Working at this level is not only the most feasible from a cost-effectiveness perspective, but it also allows us to examine heterogeneity in pass-through across many different markets. As one moves further down the supply chain, the number of markets for cocoa necessarily falls quite quickly.

As the summary statistics presented below will show, the provision of loans by traders to farmers is a defining characteristic of this industry, making the context similar to those in other developing economies discussed in the papers cited in the introduction. Traders will offer farmers credit before and during the harvesting season, which typically lasts from the beginning of the rainy season in July until early January of the following year. Traders then allow farmers to repay the loan in cocoa by selling at a below market price for subsequent sales until the loan has been repaid. This credit could be productive, and allow the farmer to invest in post-harvesting quality-enhancing processing (i.e. fermenting and drying the cocoa beans), or could be simply a payment advance that the farmer uses for consumption.

Traders also use credit provision as compensation for the guarantee that the farmer will sell to them at harvest, "locking in" supply, preventing other traders that visit the market to compete for that farmer's cocoa. This creates a co-existence of "spot markets" (i.e. traders competing for cocoa from a given farmer after the harvest occurs) and interlinked transactions. A necessary condition for credit to generate this lock-in effect is that it must be costly for a farmer to strategically default on the loan. This is the case in our context for at least two reasons. First, customary authorities play an important role in enforcing contracts even if access to modern courts is very limited (e.g. Acemoglu, Reed, and Robinson, 2013, Sandefur and Siddiqi, 2013). Second, as in standard relational contracting models, traders may threaten not to offer credit in the subsequent season in the event of a default (Fafchamps, 2004, 2006, Macchiavello and Morjaria, 2013).

3.2.2 Experimental Design

We developed our experiment in partnership with five privately owned wholesalers in Sierra Leone's cocoa producing Eastern Province, three in the town of Segbwema, and one each in the towns Pendembu and Kailahun.[7] These wholesalers collect cocoa in their warehouses, and then sell it on to exporters in the provincial capital of Kenema. Our sample includes 80 traders, henceforth study traders. This comprises almost the complete set of traders who do business regularly with these wholesalers.[8]

We paid a bonus of 150 Leones—5.6% of the average wholesale price—for high quality cocoa to randomly selected traders, who themselves buy directly from farmers. The bonus in our experiment was designed to model fluctuations in the market price received by traders, who themselves sell to wholesalers. Our experiment runs from September to December of 2011, roughly the end of the harvest season. At the beginning of the experiment, traders were informed the treatment would last till about the end of the harvest season.

The bonus generates cross-sectional variation in prices received by traders during this time period. While prices do also vary over time because of international market fluctuations, these changes are not an attractive source of variation for our purposes. Such changes are infrequent, making it difficult to use them to estimate a pass-through rate unconfounded by other seasonal variables such as rainfall that may affect supply throughout the season. In addition, time series of prices and in particular credit provision the would be required for a study based on world price fluctuations are typically not available across many producer and trader relationships. For these reasons, we chose an experimental approach in our study.

We then measure how this bonus affects prices and credit delivered to farmers across the different villages in which the traders operate. By estimating heterogeneous treatment effects across villages and comparing them, we are able to study the relation between these two margins, using our model to guide the analysis.

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[7]These towns are now quite remote, accessible only by unpaved roads that can become impassible in the rainy season. During the colonial period, however, Pendembu was a prosperous trading town and the final stop on the Sierra Leone Railroad, which was dismantled and sold by the government of Siaka Stevens in the 1974. The decline in the country's cocoa industry since then can be observed at the massive abandoned produce warehouse where the end of the tracks once lay. Exporters we visited in 2011 joked with some cynicism that the cocoa stocks of the largest wholesalers in Pendembu could not come close to filling it.

[8]In a census of regular business partners of the wholesalers, we counted originally 84 traders. Two were outliers with respect to baseline quantity, and could not be matched to other traders in our randomization strategy. One other trader was lost due to attrition–he did not return after the census and no follow up data on either credit or prices could be collected. Since all of the analysis is done within matched pairs, his pair is also dropped from the analysis. Given the pairwise randomization, this attrition is not a threat to the internal validity of our study.

3.2.3 Data and Random Assignment

Trader Data

Randomization occurred at the trader level. To improve the statistical power of our experiment, we implement a pairwise randomization strategy, first grouping traders in pairs and then allocating one trader to treatment in each of the pairs (Bruhn and McKenzie, 2009). We first match traders within wholesalers according to a self-reported estimate of the number of grade A bags that they had sold since the beginning of the cocoa season, a plausible proxy for the scale of their business. We felt this a useful proxy for similarity in capacity for price and credit pass-through, since the ability to give credit will be a function of the total wealth of the trader, which, given constant or increasing margins, should rise with the scale of business. Having matched the traders, we assigned treatment and control within pairs using a random number generator.

Over the course of the experiment we collect a variety of data from traders. Summary statistics are presented in Table 3.1. At baseline, we interviewed each trader about their experience in the industry, and collected basic demographic indicators. These results are presented in Panel A of Table 3.1. Traders operate at a small scale in terms of value. At average cocoa prices and 2011 exchange rates, the self-estimate of bags sold per trader since the beginning of the season is approximately $4,360.[9] Traders are experienced, with an average of 6.5 years selling to the wholesaler. Their average age is 38 years, 82% of the 46 year male life expectancy reported by World Health Organization in 2011. Traders are well off relative to the population. 58% have a cement or tile floor as opposed to dirt or thatch, a useful indicator of asset wealth in this context, and 92% own a mobile phone. The 2007 National Public Services survey of reports 18% and 8% respectively for ownership of these two assets among all households in rural areas. 83% of traders have access to a storage facility.[10] The third column of Table 3.1 shows that treatment and control are balanced on all trader-level covariates.

During the experiment, when traders arrived at the warehouse, inspectors from our research team measured and documented the quality of their shipment. We collected these data for about

[9]This is calculated as the control group's average number of bags, 30.3, times the approximate pounds per bag, 180 times the average dollar price of cocoa over this period, Le. 3,200, divided by 4,000, the nominal exchange rate.

[10]Field work suggests that traders for the most part do not perform long-term storage or other post-harvest processing activities.

Table 3.1: *Trader summary statistics*

Covariate	Treatment	Control	Treatment - Control
Panel A: Baseline Interview			
Self-estimate bags sold in 2011	32.8	30.3	2.5
			(6.7)
Self-estimate grade A bags sold in 2011	20.0	18.6	1.4
			(5.4)
Age, years	38.2	36.9	1.3
			(2.1)
Years selling to study wholesaler	5.7	7.3	-1.4
			(1.1)
Cement or tile floor in house $\in \{0, 1\}$	0.53	0.62	-0.09
			(0.1)
Mobile phone owner $\in \{0, 1\}$	0.90	0.93	-0.03
			(0.06)
Access to storage facility $\in \{0, 1\}$	0.88	0.78	0.10
			(0.09)
Panel B: Pre-treatment shipment data			
Cocoa (pounds) sold during pre-treatment	2,478	2,594	117
			(673)
Grade A (pounds) sold during pre-treatment	639	1,022	-382
			(380)
Per pound farmer price for Grade A (Leones)[a]	3,120	3,165	-45
			(55)
Per pound farmer price for Grades B or C (Leones)[b]	3,066	3,050	16
			(30)
Panel C: Baseline farmer listing			
Villages operating in	4.87	4.25	0.62
			(0.41)
Number of farmers buying from	18.7	20.5	-1.8
			(3.1)
Mean number of farmers per village	5.6	5.8	-0.2
			(0.8)
Share of farmers given credit since March	0.688	0.694	-0.006
			(0.0704)
Number of observations	40	40	

Notes: Standard errors allowing for unequal variance between groups in parenthesis. Treatment and control assigned randomly within pair of matched on self-estimates of grade A bags sold in 2011.[a] There are only 22 treatment observations of the grade A price in pre-treatment shipments, and 24 control.[b] There are only 30 treatment observations of a grade B or C price in pre-treatment shipments, and 34 control.

two weeks before treatment assignments were announced. Panel B of Table 3.1 shows deliveries from this period. Given the short length of pre-treatment period data collection, we miss baseline data for some traders and markets (details reported in the table notes). These results confirm that treatment and control traders are balanced on the volume of their business: treatment traders sold on average 2,478 pounds and control traders sold 2,594. Treatment traders did sell a lower amount of grade A cocoa, but the difference is not statistically significant (T = -1.005).

In these shipment data, we collected the price per pound paid to farmers, and the name of the village in which the cocoa was purchased. As emphasized by Atkin and Donaldson (2013), it is important to measure prices only for narrowly defined homogenous goods, as one must not conflate pass-through and changes in the composition of quality. The quality of cocoa is indeed heterogeneous, and market prices depend on a variety of characteristics including moisture content, mold, germination, lack of fermentation and a discoloration known as slate. Though there is no official measure of quality in the market, wholesalers and traders agree on broad determinants of quality that are consistent with international standards (see CABISCO, 2002). A quality premium exists in the market to some extent. In order to measure pass-through for given classes of quality, we worked with the partner wholesalers to refine a quality grading that correlates well with baseline prices. When traders arrive at the warehouse, inspectors hired by the research team sampled 50 beans from each bag, and used them to create an index of quality—grades A, B or C—which was then applied to each bag. In Appendix C.1 we discuss in greater detail the construction of the grades, and their relationship to wholesale prices and international standards of cocoa quality.

Traders typically mix cocoa from different farmers of the same village in the same bag, and so farmer prices reported are the average per unit purchase price paid by a trader in a village at the time a bag was purchased. Farmer prices reported in baseline in Panel B show that traders in treatment and control were balanced on the prices they paid to farmers, and confirm that average prices of grade A cocoa are larger than for grades B and C: in the control group the average price paid for grade A is Le. 3,120 and the average price paid for B or C is Le. 3,050.

Finally, in the baseline we asked traders to list each farmer they buy from regularly and all of the villages in which they buy. For each farmer, we asked whether the trader had given the farmer a loan over the past 12 months. These results are shown in Panel C. The average trader operates in 4.6 villages, and buys from 25.9 farmers, on average 5.7 per village. In the baseline survey traders have given at least one loan to on average 70% of their clients. In order to study the impact of trader treatment on credit provision, in November and December we asked again the traders if they had given loans in the previous month to the farmers listed at baseline, in the final round asking the amount of the last loan.

One caveat to our empirical analysis is that, due to budget constraints, all the data are self-reported by traders when they visit the wholesaler warehouses. In Section 3.5, we argue that our results cannot be explained by strategic misreporting.

Village Data

In the baseline, we confirmed the existence of 125 villages in which study traders had reported purchasing cocoa over the previous year. For our analysis, we focus on the eighty villages for which we have at least one observation of the grade A during the study period.[11] Figure 3.1 presents a map of these villages along with the major towns, and the road network, which is unpaved. Panel A of Table 3.2 presents summary statistics from this sample of villages. On average, each village has 3.2 study traders, and 1.5 treatment traders. 34 of our 80 sample villages have at least one treatment and one control trader. This merits some concern about spillover effects between treatment and control. We address this concern directly in Section 3.3. As can be seen in Figure 3.1 the average road distance from a village to the nearest town is relatively short, at 9.6 miles using Dijsktra's minimum distance algorithm along the road network. Importantly, on average 65% of farmers selling to study traders have been given credit by at least one trader over the last year, highlighting the importance of interlinked transactions in this industry.

[11]Ninety-two villages had at least one sale of cocoa during the experiment. Since we are interested in looking at the relation between heterogeneity across markets of treatment effect on grade A prices and credit provision, we choose to conduct the analysis on villages with at least one sale of grade A. The results presented in section 3.3.2 are similar when using the sample of ninety-two markets with at least one purchase of any cocoa during the experiment (results are available on request).

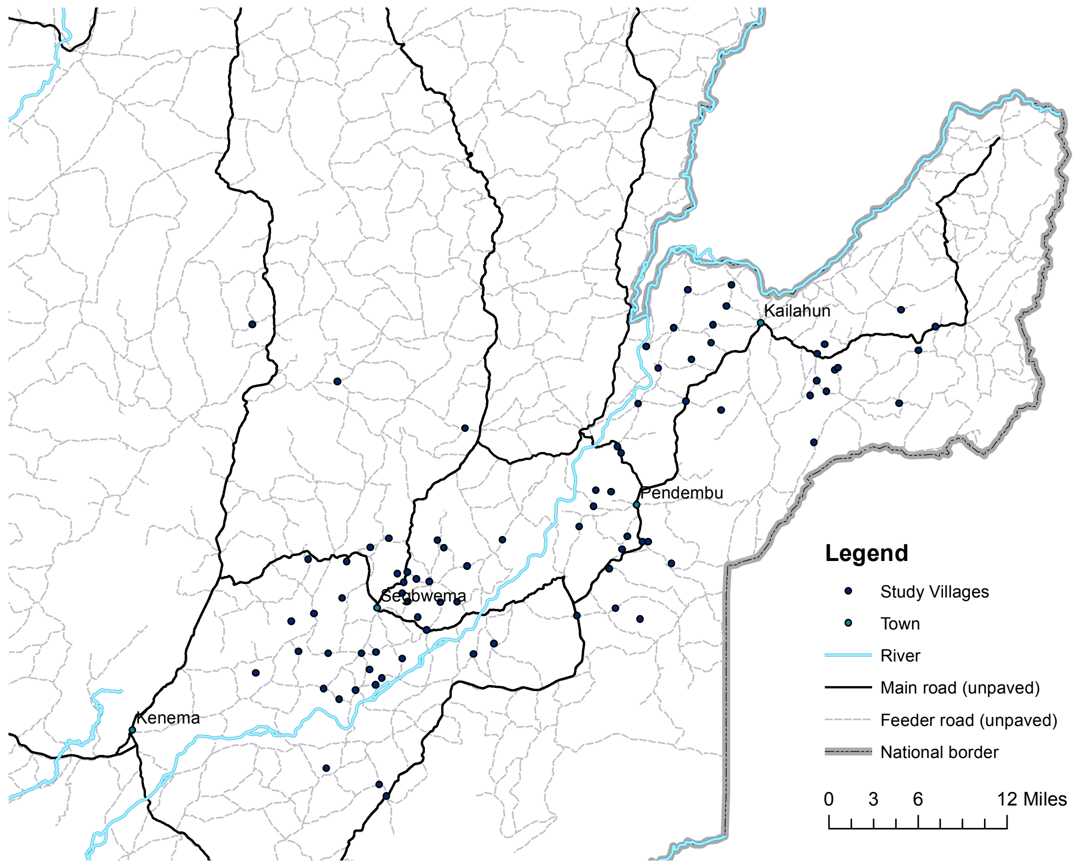

Figure 3.1: *Map of study villages*

Randomization across traders randomly allocates treatment traders to sets of villages conditional on the number of study traders in the village. Since we will estimate heterogeneous treatment effects across villages, it is important to check whether villages are balanced in the composition of treatment and control traders. Panel B of Table 3.2 presents the coefficients of a regression of a village level covariate on the number of treatment traders and number of study traders as a test of balance. In all cases, the coefficient on the number of treatment traders are not statistically significant.

3.3 Experimental Results

In this section, we present the average treatment effect results from our experiment. We first document the negligible effect of the bonus on prices paid to farmers and show that the lack of price pass-through cannot be explained by increasing marginal costs of transport. We then show that the traders respond to the bonus by increasing credit provision to farmers. In section 5, we complement these results with an analysis of heterogeneous treatments across villages motivated by the theoretical framework we develop in section 4. Throughout the paper, the standard errors we report are robust to heteroskedasticity and are estimated with two non-nested clusters that allow for arbitrary correlation across observations from a given village, and across observations from a given trader. This clustering approach follows Cameron, Gelbach and Miller (2011).

3.3.1 Price Pass-Through

To study pass-through in prices, we estimate the following regression, where an observation is a shipment k delivered by trader i of randomization pair p, from village v in week t:

$$Price_{kivt} = \alpha_p + \tau_t + \theta^p(\text{Bonus}_i) + \mathbf{X}_i'\boldsymbol{\beta_x} + \mathbf{W}_v'\boldsymbol{\beta_w} + \epsilon_{kitv} \tag{3.1}$$

We include a number of variables to control for variation in the trader's expected resale price over time, which may itself affect the price paid to the farmer. The term α_p is a fixed effect for each matched pair in the randomization. Since pairs were matched within wholesalers, this effectively controls for the town in which the trader sells his cocoa. The term τ_t is a week fixed effect, to capture time varying factors in supply, such as weather, as well as any variation in the expectation

Table 3.2: *Village summary statistics*

Village covariate	# of study traders	# of treatment traders	Miles to nearest town	Baseline credit share	Total farmers reported by traders
Panel A: Sample averages					
Mean	3.2	1.5	9.6	0.65	18.7
	(2.4)	(1.5)	(5.7)	(0.29)	(16.4)
Number of observations	80	80	80	80	80
Panel B: Balance in count of treatment traders across sample villages					
# of treatment traders			0.79	0.01	0.02
			(0.66)	(0.03)	(1.50)
# of study traders			-0.28	0.02	5.24
			(0.41)	(0.02)	(1.03)
Number of observations	80	80	80	80	80

Notes: Panel A shows means of study sample of villages with standard deviations in parenthesis. Panel B shows the coefficients in a regression of the covariate (the column header) on the number of treatment traders, the number of study traders and a constant. Robust standard errors are presented in parentheses in panel B. Miles to nearest town calculated using Dijkstra's minimum distance algorithm along the network of rural feeder roads. Baseline credit share and total number of clients reported in a baseline listing of all clients in each village.

of the wholesaler price that may fluctuate over time. The vector $\mathbf{X}_i'$, used in some specifications, includes the trader controls of baseline values of pounds of grade A sold, number of villages operating in, number of suppliers buying from, share of clients given credit in baseline, age, years of working with wholesaler, and dummies for ownership of a cement or tile floor, mobile phone and access to a storage facility. The vector $\mathbf{W}_v'$ includes the village-level covariates of baseline share of suppliers begin given credit, number of other bonus traders and number of study traders, miles to nearest town, and number of clients across all traders, and also five fixed effects for village chiefdoms, which are local units of legal and political administration. Bonus_i is a dummy equal to one if trader i is assigned to treatment, and so θ^P is the average treatment effect, conditional on the other controls. The term ϵ_{kitv} is an error. Pairwise randomization motivates the assumption that $E[\epsilon_{kitv}|\text{Bonus}_i, \alpha_p, \tau_t, \mathbf{X}_i', \mathbf{W}_v'] = 0$, which ensures that θ^P is estimated without bias.

The term θ^p is the coefficient of interest. Recall that the bonus was Le. 150 per pound. If $\theta^p = 150$, we have perfect pass-through, as the treatment traders will have increased the price paid to farmers by the full amount that their resale price increased by. Table 3.3 presents estimates of θ^p. In the basic specification in column 1, which includes only randomization pair and week fixed effects, with no village or trader covariates, pass-through is statistically indistinguishable from zero, with a point estimate of $\theta^p = -5.4$ (s.e. = 14.9). Even at the upper bound of a 95% confidence interval, pass-through would be just 24 Leones, less than one fifth of the amount of the bonus, 150 Leones. This extremely low level of pass-through to farmgate prices is consistent with the evidence provided by Mitra et. al. (2013) and Fachamps and Hill (2008).[12]

Given that some villages contain both treatment and control traders, we are concerned that spillovers between groups may be driving this result. It may be that Bertrand style competition between treatment and control traders drives up the price offered by control traders within a village, so that there is no difference between the prices offered by both groups. We test this hypothesis directly by adding the number of other study traders and other treatment traders in column 2. If this were occurring, the number of other treatment traders in the village should raise prices independent of the effect of the treatment. We find little evidence of this, as the coefficient on this variable is small and statistically insignificant; even the upper bound of the 95% confidence

[12] Adhvaryu et al. (2013), in Tanzania, finds higher level of local price responsiveness to world price though still far from perfect pass-through.

Table 3.3: *Farmer price response*

Price	(1) Grade A	(2) Grade A	(3) Grade A	(4) Grade A	(5) Grade A (alt.)
Bonus	-5.4	-5.5	-11.0	-7.0	-3.6
	(14.9)	(13.8)	(19.5)	(13.2)	(15.1)
# Other bonus traders		8.8	3.3	7.3	
		(7.4)	(10.0)	(7.0)	
(Bonus $\times$ # Other bonus traders)			7.7		
			(10.7)		
# Other traders		-10.7*	-9.8	-4.3	
		(5.7)	(7.4)	(6.1)	
(Bonus $\times$ # Other traders)			-1.6		
			(6.6)		
R^2	0.90	0.90	0.90	0.91	0.89
Number of observations	1,090	1,090	1,090	1,071	1,090
Chiefdom fixed effects	NO	NO	NO	YES	NO
Village controls	NO	NO	NO	YES	NO
Trader controls	NO	NO	NO	YES	NO

Notes: Robust standard errors in parenthesis allow for two-way, non-nested clustering at the village and trader level. All specifications include calendar week and randomization pair fixed effects. An observation is a shipment delivered to a wholesaler, and prices are per pound in Leones. Bonus is a dummy for whether the trader recieved an increase in the resale price of 150 Leones per pound for grade A only, and so perfect pass-through would imply a coefficient of 150 on the bonus indicator in columns 1, 2, 4 and 5. There were approximately 4,000 Leones to the U.S. dollar at the time of the study. The alternative measure of price in column 5 is the total price paid to the farmers divided by weight of shipment. Trader controls are baseline values of pounds of grade A sold, number of villages operating in, number of suppliers buying from, share of clients given credit in baseline, age, years of working with wholesaler, and dummies for ownership of a cement or tile floor, mobile phone and access to a storage facility. Village controls are baseline share of suppliers begin given credit, number of other bonus traders and number of study traders, miles to nearest town, and number of clients across all traders. Trader and village controls are summarized in Tables 3.1 and 3.2, respectively. *** $p<0.01$, ** $p<0.05$, *$p<0.1$

interval is still very low (23 Leones).

There is also concern that low pass-through occurs because the trader with the bonus faces little competition from other traders with the bonus. In column 3, we test the hypothesis by testing whether pass-through is larger in villages with multiple treatment traders. In these villages, competition between treatment traders would potentially create more pass through, better approximating a price increase available to all traders in the village. To do this, we interact the two market level trader counts with the treatment status of the trader. This is a specification similar to the one developed to test for externalities by Kremer and Miguel (2004). The estimate of $\theta^p = -11 (s.e. = 19.5)$ can be interpreted as predicted pass-through in a village with no other treatment or control traders. We do find some evidence that treatment traders pay a higher price when there are other treated competitors in the market, but the coefficient on the interaction is not significant at standard levels. Even with multiple traders receiving the bonus, there is limited pass through in the market.

Column 4 uses both chiefdom fixed effects and the vectors of village-level and individual-level controls. Again the low pass-through result is robust. Column 5 presents the same regression using as our outcome an alternative measure of price taken by dividing a bag total expenditure by its weight. This provides reassurance that our price results are not driven by measurement error in prices. [13]

In a perfectly competitive model of spatial arbitrage, the difference in price between two locations that trade will equal the marginal cost of transport. A natural explanation for our lack of pass-through could be simply that marginal costs of transport are increasing rapidly for treatment traders. Table 3.4 presents estimates of equation (3.1), with outcomes related to cost in the place of $Price_{kivt}$, using all grades of cocoa shipped. In columns 1 and 2, we see that unit costs reported by the trader are also falling. In the preferred specification with chiefdom fixed effects and village and trader controls we have that the treatment effect is -8.4 Leones (s.e. = 2.1). This implies that in

[13] In results not presented, we also tested for effects on the prices of B and C grade cocoa. Though we found no significant effect on the price of grade C cocoa, we did find a statistically significant effect on grade B prices (the point estimate is 37, which is still very far from perfect pass through). Field interviews suggest that this result is a result of Type I error on the part of traders, who observe quality imperfectly. The bonus has increased the expected price for grade A quality cocoa relative to grade B. Even if pass-through is zero for a given quality, if quality is imperfectly observable traders will now be more willing to pay the grade A price premium for cocoa that has some probability of being grade A.

Table 3.4: *Transport cost and technology choice response*

Variables	(1) Unit cost	(2) Unit cost	(3) Truck use	(4) Truck use
Bonus	-11.9***	-8.4***	0.20***	0.21***
	(3.5)	(2.1)	(0.06)	(0.04)
R^2	0.49	0.57	0.49	0.53
Number of observations	1,089	1,070	1,089	1,070
Chiefdom fixed effects	NO	YES	NO	YES
Village controls	NO	YES	NO	YES
Trader controls	NO	YES	NO	YES

Notes: Robust standard errors in parenthesis allow for two-way, non-nested clustering at the village and trader level. All specifications include calendar week and randomization pair fixed effects. An observation is a shipment delivered to a wholesaler. Bonus is a dummy indicating a treatment trader. Costs in columns 1 and 2 are per pound in Leones, with a control group mean (s.d.) of Le. 47 (29); truck use in columns 3 and 4 is a dummy indicating whether a hired truck was used for transport, with a control group mean of 0.39. There were approximately 4,000 Leones to the U.S. dollar at the time of the study. Trader controls are baseline values of pounds of grade A sold, number of villages operating in, number of suppliers buying from, share of clients given credit in baseline, age, years of working with wholesaler, and dummies for ownership of a cement or tile floor, mobile phone and access to a storage facility. Village controls are baseline share of suppliers begin given credit, number of other bonus traders and number of study traders, miles to nearest town, and number of clients across all traders. Trader and village controls are summarized in Tables 3.1 and 3.2, respectively. *** $p<0.01$, ** $p<0.05$, *$p<0.1$

addition to the bonus of 150 Leones per unit, traders also received a gain in the form of lower transport costs per pound shipped. Finally columns 3 and 4, which amount to a linear probability model in which the outcome variable is a dummy indicating that a truck and not a motorcycle was used to transport the cocoa, show that this cost result is potentially driven by a change in transport technology. Trucks, on average, have consistently lower per unit costs. These results show that the lack of pass-through cannot be explained by increasing marginal costs.

3.3.2 Credit

To investigate the effect of the bonus on credit, we estimate the following regression, which is a modified version of (3.1):

$$Credit_{fiv} = \alpha_p + \theta^c(\text{Bonus}_i) + \mathbf{X_i'}\boldsymbol{\beta}_x + \mathbf{W_v'}\boldsymbol{\beta}_w + {}^\circ{}_{\mathbf{fiv}} \tag{3.2}$$

An observation is a farmer. $Credit_{fipv}$ is an indicator of whether farmer f in village v was given credit by trader i of pair p during the course of the experiment (i.e. between September and December). The term θ^c is the treatment effect estimator, and ν_{fipv} is an error term. All other terms are as in (3.1). Pairwise randomization again motivates the assumption that $E[\nu_{fipv}|\text{Bonus}_i, \alpha_{ip}, \mathbf{X}_i', \mathbf{W}_v'] = 0$.

Table 3.5 presents estimates of the θ^c in equation (3.2). In column 1 we run a linear probability model where the outcome is a dummy equal to one if credit was provided to a farmer. The treatment effect on credit is substantial: farmers reported as regular suppliers by treatment traders in the baseline listing are 14 percentage points more likely to receive credit from these traders relative to a control mean of 12 percentage points. Columns 2 and 3 test for potential spillovers. The presence of other traders in the village, treatment or control, does not alter our results. Column 4 shows that the results are robust when adding chiefdom fixed effects, and trader and village controls. In column 5 we see the result in terms of Leones. Here, traders were asked after two months of treatment the amount of the loan last given to the farmer, if any was given in the past month. Farmers that did not receive any have values of this outcome equal to zero. We see that traders are raise their credit outlay by approximately 50%, with $\theta^c = \text{Le. } 9,771$ (s.e. = 5,209), off a control group mean of Le. 18,908.

In sum, we cannot reject that pass-through of the bonus in terms of prices is zero, but we find substantial average effects on credit provision to the farmers.

3.4 A Model of Pass-Through in Interlinked Transactions

In this section, we develop a simple model that describes the rate of price pass-through in the presence of interlinked transactions. The model draws from the broad theoretical literature on interlinkages.[14]. Most closely related is the work of Chaudhuri and Banerjee (2004), who endogenize the emergence of interlinked credit-product markets and study how these interlinkages respond to trade liberalization. We add to this framework strategic default considerations in the farmer-trader relation, and highlighting the relationship between credit responsiveness and price pass-through following a change in the price the trader receives.

[14] A helpful summary is given by Basu and Bell (1991

Table 3.5: *Credit response*

Variables	(1) Lent	(2) Lent	(3) Lent	(4) Lent	(5) Amount lent
Bonus	0.14***	0.14***	0.11*	0.13***	9,771*
	(0.03)	(0.03)	(0.07)	(0.03)	(5,209)
# Other bonus traders		-0.01	-0.00	-0.01	
		(0.01)	(0.02)	(0.01)	
(Bonus × # Other bonus traders)			-0.01		
			(0.02)		
# Other traders		0.01	0.00	0.01	
		(0.01)	(0.01)	(0.01)	
(Bonus × # Other traders)			0.01		
			(0.02)		
R^2	0.31	0.31	0.31	0.35	0.57
Number of observations	1,541	1,541	1,541	1,529	1,541
Chiefdom fixed effects	NO	NO	NO	YES	NO
Village controls	NO	NO	NO	YES	NO
Trader controls	NO	NO	NO	YES	NO

Notes: Robust standard errors in parenthesis allow for two-way, non-nested clustering at the village and trader level. All specifications include calendar week and randomization pair fixed effects. An observation is a farmer listed by the trader in the baseline. The dependent variable in columns 1-4 is an indicator for whether the trader lent any money to the farmer during the duration of the experiment. The control mean of this dummy was 0.12. The dependent variable in column 5 is the amount lent in Leones during the last month of the experiment. The control mean of this amount was Le 18,908 (s.d. = 52,597). Trader controls are baseline values of pounds of grade A sold, number of villages operating in, number of suppliers buying from, share of clients given credit in baseline, age, years of working with wholesaler, and dummies for ownership of a cement or tile floor, mobile phone and access to a storage facility. Village controls are baseline share of suppliers begin given credit, number of other bonus traders and number of study traders, miles to nearest town, and number of clients across all traders. Trader and village controls are summarized in Tables 3.1 and 3.2, respectively. *** $p<0.01$, ** $p<0.05$, *$p<0.1$

The model makes three contributions that aid the interpretation of the empirical results. First, it generates the simple insight that the transaction price received by those transacting on a spot market differs from that of the farmers who are in the interlinked transaction contracts. In the latter, the price received is co-determined with the terms of a loan. The rate of price pass-through is then determined by the measure of people to whom the trader becomes willing to extend credit after the resale price has changed. There is a direct mapping here to the empirical results presented above. Our bonus expanded credit on the extensive margin—a greater number of farmers received credit. This effect can contribute to explain the low rate of price pass-through observed. We will test this conjecture in the next section by showing that it is precisely the markets in which credit pass-through is high that exhibit low price pass-through.

Second, the model generates additional testable predictions about the cross sectional variation of credit supply with other variables across markets. It describes the relation between credit provision and farmer prices, and determines the conditions under which the two will be negatively related across markets. The model also predicts that credit supply should be greater in markets where the return to giving credit for the trader is higher. In the model we allow for the returns to credit to vary along two dimensions, both of which are relevant in our setting. Traders are more likely to give credit when the number of traders in the market is greater and they have more to gain from a credit contract that "locks in" the farmer's produce and protects it from competition. Traders will also give more credit when the quantity of cocoa available per farmer is greater. We will verify both of these predictions in the Section 5.

Third, we contrast the welfare implications of this model with those of a benchmark model that does not account for interlinkages, showing that low price pass-through need not, as it does in the benchmark model, imply that farmers receive a low share of surplus relative to traders.

3.4.1 The Economy

Our economy is composed of M isolated markets. Each market m is populated by I_m farmers and J_m traders. Interactions between the two agents in each market can occur under two alternative contracts. In the *spot market*, the trader and farmer transact only at harvest time. This contract can be viewed as that which occurs in a benchmark model with no interlinkages. In *interlinked* *transactions* (ILT), a trader provides credit before harvest and then purchases output from the farmer at harvest, unless the farmer chooses to default.

Traders are homogeneous. Farmer i in market m is endowed with an amount of land, which varies across farmers within a market. If the farmer does not receive credit, the land produces a fixed quantity q_{im}, which we will write as q_i to reduce notation. If the farmer receives credit, the land is assumed to produce $q_i(1+r)$. In the limiting case of $r = 0$, the credit relationship will still be valuable to both the farmer and trader for two reasons. In addition, the farmer receives some consumption smoothing benefit from the loan, and the trader can extract some of this benefit by lending. Field work suggests that credit plays both these roles, and so we allow for them all in the model. Because of these consumption benefits, all of the predictions discussed below obtain with $r = 0$.[15] Finally, giving credit allows the trader to "lock in" the quantity produced by the farmer. Since strategic default on the loan is costly for the farmer, a trader that privides credit reduces the level of competition for cocoa from a given farmer.

We now discuss the payoff structure of the agents under the two types of contracts, spot market and ILT. Throughout, we assume farmers and traders are risk-neutral and maximize their expected profits.

The Spot Market

Spot market prices in market m, p^S_m, are equal to the wholesale price over a constant markdown,

$$p^S_m = \frac{w_m}{\mu}, \quad \mu \geq 1 \tag{3.3}$$

The markdown is a reduced form capturing trading costs proportional to value, price rigidity and any market power the trader may have. The utility of farmer i in market m transacting on the spot market is:

$$u^S_{im} = p^S q_i = \frac{w_m}{\mu} q_i \tag{3.4}$$

On the spot market, we assume that each trader has an equal probability to secure cocoa from a given farmer in market m equal to $1/J_m$. Therefore, the expected utility for trader j transacting

[15] We can also interpret output as quality-adjusted production. Credit allows farmers to increase quantity of a given quality by investing in post-harvesting processing, such as fermenting and drying. Such activity is costly, and so may require financing through credit.

with farmer i in market m is:

$$v_{jim}^{S} = \frac{1}{J_m}(w_m - p_m^S)q_i = \frac{1}{J_m}\frac{\mu - 1}{\mu}w_m q_i \tag{3.5}$$

Interlinked Transactions

In interlinked transactions, a trader provides credit before harvest, and subsequently purchases output at a pre-determined price. The contract stipulates a price, and the farmer's guarantee that the trader will receive all the farmer's produce once available. We assume that traders and farmers are randomly matched ex-ante and that only one trader can offer credit to a given farmer. In order to provide credit, the trader incurs a fixed cost f. This can be interpreted as the minimum amount of screening and monitoring that trader needs to undertake, independent of the amount of credit outlay (for a review of these issues, see Banerjee, 2002). We assume that if the two parties enter an interlinked transaction, the trader provides a fixed amount of credit per each bag denoted by c. In addition to the potential impact of credit on production levels if $r > 0$, we assume that the farmer also receives a utility benefit from the loan of $c_F = \lambda \cdot c$, with $\lambda > 1$. This is a reduced form for the increased utility of the farmer from extra pre-harvest consumption, which is assumed to be weakly larger than the trader utility cost of disbursing the loan.[16] One way to think about this is that the farmer experiences a higher marginal utility per unit of income in the pre-harvest season.

After receiving credit, the farmer decides whether to stick to the terms of the contract or to default. If the farmer respects the contract, he receives a farmer-specific contract price p_{im}^{C} and pays back the loan, c. We describe how this price is determined in equilibrium in section 3.4.2. When the farmer does not default, the utility of farmer i under ILT is

$$u_{im}^{CN} = (p_{im}^{C}(1+r) + (\lambda - 1)c)q_i \tag{3.6}$$

and the utility for trader j in an ILT contract with farmer i is

$$v_{jim}^{CN} = ((w_m - p_{im}^{C})(1+r))q_i - f \tag{3.7}$$

Note here that the trader's utility no longer includes the term $1/J_m$, since in the interlinked

[16]We abstract from the investment optimization problem the farmer faces when receiving credit.

transaction contract, he is now certain to get the farmer's output (if the contract is enforced).[17]

The benefit of strategic default for the farmer depends on the underlying contracting institutions in market m. Specifically, we assume that, if the farmer defaults, he loses a share γ_{im} of his output. We do not consider partial default. After defaulting on the loan, he sells $(1-\gamma_{im})q_i(1+r)$ on the spot market. The parameter γ_{im} is broadly a measure of the quality of contracting institutions, capturing market characteristics that could shape the cost of default, including the trader's monitoring costs, the reliability of local chiefs in enforcing contracts, and social norms specific to farmer i.

If he defaults, the utility of farmer i in the ILT contract is

$$u_{im}^{CD} = \left(p_m^S(1-\gamma_{im})(1+r)+\lambda c\right)q_i = \left(\frac{w_m}{\mu}(1-\gamma_{im})(1+r)+\lambda c\right)q_i, \tag{3.8}$$

and the utility of trader j matched to farmer i is

$$v_{jim}^{CD} = -c \cdot q_i - f \tag{3.9}$$

3.4.2 The Equilibrium Contract

Here we describe the conditions under which farmers and traders will opt to transact on the spot market or in an ILT contract. We also determine the equilibrium contract price under ILT. The timing of the game is as follows: in the first stage, the trader is randomly matched to the farmer, and decides whether to offer credit. He also decides the terms of the contract—the contract price at which output will be sold after harvest, p_{im}^C. If the trader does not offer credit, the farmer sells on the spot market. If the trader does offer credit, the game proceeds to the second stage and the farmer decides whether to accept or not. In the third stage, the farmer decides whether to default or not, conditional on having accepted the ILT. We solve the model by backwards induction and restrict our analysis to subgame-perfect Nash equilibria. In the third stage, the farmer decides not to default if

$$u_{im}^{CN}(p_{im}^C) \geq u_{im}^{CD}. \tag{3.10}$$

[17] An alternative interpretation of this setup, suggested to us by Chris Udry, is that the J traders in a given village form a cartel—hence the markdown μ—and that traders use credit as non-price, less visible tool to defect on the collusion agreement.

This is the farmer's incentive compatibility constraint, which highlights the fact that the decision to default depends on the proposed contract price, p^C_{im}. In order to prevent default, the trader must offer a large enough contract price to satisfy this inequality.

In the second stage, if the trader offers credit and a contract price in the first stage, the farmer must decide whether to accept it. The farmer accepts credit if

$$\max\left(u^{CN}_{im}(p^C_{im}), u^{CD}_{im}\right) \geq u^S_{im}. \tag{3.11}$$

This is the farmer's participation constraint.

In the first stage, the trader decides whether to offer credit and, if so, the contract price to offer. As is common in the principal-agent literature, we focus on the equilibrium in which the trader has all the bargaining power and sets the price so to maximize his profit conditional the farmer's incentive compatibility and participation constraints. The main comparative statics described in Section 3.4.3 however do not depend on this particular equilibrium selection.

The contract price will depend on which of the farmer's constraints bind, (3.10) or (3.11), which depends on the quality of contracting institutions. For low levels of γ_{im}, the farmer's incentive compatibility constraint binds, and the price must be set to ensure no default. Specifically this condition is $\gamma_{im} < \frac{r}{1+r} + \frac{c\lambda\mu}{w(1+r)} \equiv \hat{\gamma}_1$. For higher levels of γ_{im}, the farmer's participation constraint binds. Contract enforcement is so good that the farmer always prefers not to default once he accepts the loan, but the equilibrium price must be chosen high enough so that he accepts it in the first place. Given these conditions, we can summarize the price under the ILT contract as:

$$p^{C*}_{im} = \begin{cases} \frac{w_m}{\mu}(1-\gamma_{im}) + \frac{c}{1+r} & \text{if } \gamma_{im} \leq \hat{\gamma}_1 \\ \frac{w-(\lambda-1)c\mu}{\mu(1+r)} & \text{if } \gamma_{im} > \hat{\gamma}_1 \end{cases} \tag{3.12}$$

which is weakly decreasing in γ_{im}.

It is crucial to note the relationship between the contract price and the spot market price. When γ_{im} is above a minimal threshold $\hat{\gamma}_2 \equiv \frac{c\mu}{w(1+r)} < \hat{\gamma}_1$, the contract price, p^{C*}_{im} is smaller than the spot market price. It is under this condition that switching between the spot market and ILT could lower average transaction prices in the market. On the other hand, when $\gamma_{im} < \hat{\gamma}_2$ the trader needs to pay a price (weakly) larger than the spot market one to prevent strategic default. The trader is still willing to do so however because he is getting the benefit of additional quantity, either through increased production, or in expectation through the lock-in effect.

Finally, we consider the trader's participation constraint. Having now determined the optimal price, p^{C*}_{im}, the trader decides to offer credit to farmer i if

$$v^{CN}_{jim}(p^{C*}_{im}) \geq v^{S}_{jim} \tag{3.13}$$

Interlinked transaction contracts arise as the equilibrium contractual form if the inequality in equation 3.13 holds. In this equilibrium, the price in the interlinked transaction contract is described by Equation 3.12.

To build intuition for our empirical results, we now consider the case where farmers vary by their baseline production level, q_i but contract institutions vary only at the market level, denoted γ_m. The spot-market markdown μ, and the consumption smoothing benefit to the farmer λ are assumed to be constant across markets. Intuitively, traders provide credit only to those farmers whose quantities are large enough that the increase in trader revenues arising from credit provision more than offsets the fixed cost f. Specifically, farmer i and trader j in market m enter an ILT arrangement if $q_{im} > q^*_m$, where:

$$q^*_m = \begin{cases} \infty & \text{if } \gamma_m \leq \frac{cJ\mu - (J(1+r)-1)w(\mu-1)}{J(1+r)w} \equiv \hat{\gamma}_3 \\ \frac{fJ_m\mu}{w_m(J(1+r)-1)(\mu-1)+J(1+r)\gamma_m w_m - cJ_m\mu} & \text{if } \hat{\gamma}_3 < \gamma_m \leq \hat{\gamma}_1 \\ \frac{fJ_m\mu}{w_m(J-1)(\mu-1)+Jr\mu w_m - cJ_m(\lambda-1)\mu} & \text{if } \gamma_m > \hat{\gamma}_1 \end{cases}$$

In markets with very poor contracting institutions, and $\gamma_m \leq \hat{\gamma}_3$, no farmers receive credit. When the ILT does emerge, we observe that the minimum production volume a farmer needs to produce to access credit is decreasing in J_m, $(1+r)$, and is increasing in f. It is also decreasing in γ_m when $\hat{\gamma}_3 < \gamma_m < \hat{\gamma}_1$ and the farmer's incentive compatibility constraint binds. All of these results are intuitive; credit provision increases when the relative benefit for the trader from interlinked transactions increases. This occurs when: a) the number of competitors increases, raising the benefit of lock in; b) the productive returns to credit increase; c) the fixed cost from credit provision decreases; and d) the quality of contracting institutions increases, and thus the contract price the trader has to offer to induce no-default falls. In equilibrium, the contractual form preferred by the trader determines the price each farmer pays. Farmer i sells on the spot market sell at $p_{im} = p^S_m$, and farmers in an ILT sell at $p_{im} = p^{C*}_{im}$

3.4.3 Pass-Through

We now study the impact on transaction prices of an increase in the wholesale price at which the trader can resell the output bought from farmer, w_m. We continue to assume that q_{im} is the only parameter varying across farmers in a given market, and that μ and λ are constant everywhere. We also continue to assume that γ_m is constant within a market, but the insights of the analysis are identical if we relax this assumption.

The relative profit for the trader of transacting under interlinked transaction rather than spot markets, $v^{CN}_{jim} - v^{S}_{jim}$ is increasing in w_m. As the trader has higher returns from purchasing cocoa, the return from giving credit increases. Those farmer-trader pairs for which the difference changes from negative to positive will switch from spot market to interlinked transactions. The transaction price for farmer i in market m is now summarized by

$$p_{im} = \begin{cases} p^{S}_{im} & \text{if } q_{im} < q^{*}_{m}(w_m) \\ p^{C*}_{im} & \text{if } q_{im} \geq q^{*}_{m}(w_m) \end{cases}$$

Consider explicitly how p_{im} changes in response to a change in w_m from w^0_m to $w_m = w^0_m + \Delta$, where Δ is some positive constant. We restrict our attention to the case in which the contract price is determined by the farmer's incentive compatibility constraint: $\gamma_m \leq \hat{\gamma}_1$. The results are similar for higher values of γ_m. The direction and the magnitude of the change for a given farmer depends on whether the farmer is on the spot market, in an ILT, or whether the farmer switches into ILT in response to the change in w_m. There are three cases:

1. Farmers who remain on the spot market experience an increase in their price, p^S_m, of $\frac{\Delta}{\mu}$.

2. Farmers who were in ILT contracts both before and after the change in w_m experience an increase in their contract price, p^C_{im}, of $\frac{\Delta(1-\gamma_m)}{\mu}$.

3. Farmers who enter an ILT contract in response to the increase in w_m face the following change in price: $\frac{\Delta(1-\gamma_m)-\gamma_m w^0_m}{\mu} + \frac{c}{1+r}$. If $\gamma_m \geq \hat{\gamma}_2$, farmers that switch into ILT in response to the change experience a *decrease* in price as they switch from the spot price to the contract. They are however still better off, because they are now receiving credit. If $\gamma_m < \hat{\gamma}_2$, switching farmers experience an increase in price as they can threaten strategic default. Traders are however still better off because they are receiving more cocoa in expectation.

The overall rate of price pass-through is thus ambiguous. In markets with $\gamma_m > \hat{\gamma}_2$ and a large measure of people near the cut off quantity for credit, average pass-through in the market may be reduced substantially, as farmers switch from the spot market contract to ILT. Average prices may even fall. We summarize these results, and their implications for farmers' welfare in the next subsection.

This theoretical analysis of a change in the world price also provides guidance to interpret our experiment in the context of the model. While the randomization of the bonus allowed us to introduce the required variation to study price and credit responsiveness with transaction-level data, it is important to highlight some differences relative to a world price change. The main departure from the above comparative statics is that not every trader in the market receives this higher price. Therefore, one would expect the spot market price adjustment that occurs in response to the experimental variation to be lower than in the case where every trader is treated. However, the main insight of the comparative statics – that the average farmer price response depends on how the equilibrium contract (i.e., spot market vs. interlinkages) changes when trader prices go up – holds even when the treatment traders resale price is higher than the one in the rest of market. In addition, Table 3.3 showed that, on average, the price response is very limited even when there are several traders treated in the same market.[18], a scenario which is closer to a change in the world price (i.e. a change that affects all traders).

Another potential difference between our experimental variation and a change in the world price could be the transitory nature of the trader price shock. Traders may display larger price responses when they expect their prices to shift permanently. Two factors mitigate this potential discrepancy between the experiment and a change in world price. First, uncertainty also concerns fluctuations in world price: sharp reductions have often followed price increases in the last decade. Second, the trader bonus was “permanent" in the sense that the wholesalers annouced it was going to last roughly until the end of the season.

[18]Prices paid by treatment traders go up when there are other treated traders in the market, but this effect is small and non-significant.

3.4.4 Welfare Analysis With and Without Interlinkages

Here we contrast a welfare analysis of pass-through in our model with one in a model without interlinkages. Though any precise welfare calculation would depend crucially on our functional form assumptions, the analytic comparison is instructive. It emphasizes the point that in the presence of interlinkages, it is not immediate from a low level of pass-through that farmers gain little from an increase in the wholesale price.

We now assume that q_{im} is distributed according to a cumulative distribution function $G(q_{im})$ with bounded support $[q_{Lm}, q_{Hm}]$. We restrict our analysis to the case in which $q^*_m(w_m) \in [q_{Lm}, q_{Hm}]$, and both spot markets and ILT transactions occur in the market. Consider first a benchmark model in which farmers only transact on the spot market. Average welfare is given by

$$W^S = \int_{q_L}^{q_H} q\frac{w}{\mu}g(q)dq, \tag{3.14}$$

and the change in average welfare in response to a change in wholesale price is

$$\frac{dW^S}{dw} = E[q]\frac{1}{\mu} \tag{3.15}$$

Equation (3.15) shows that, in the absence of credit provision, one can simply recover the trader markdown $\frac{1}{\mu}$ from the price pass-through estimates.[19] This model then yields the intuition that low pass-through implies farmers receive on average a relatively smaller share of wholesale value than do the traders.

In our model, which accounts for interlinkages, average farmer welfare in the market is equal to:

$$W^{ILT} = \int_{q_L}^{q^*} q\frac{w}{\mu}g(q)dq + \int_{q^*}^{q_H} q\left((1+r)(\frac{(1-\gamma)w}{\mu} + \frac{c}{1+r}) + (\lambda-1)c\right)g(q)dq, \tag{3.16}$$

which is simply a weighted average of the welfare of farmers under the spot market and ILT contracts. The first term represents the welfare of farmers transacting on the spot market and the second is the welfare for farmers who are in ILT contracts. To find the average welfare effect of an

[19] This simple result obviously relies on the assumption of perfectly inelastic supply at the farmer level. In the case with elastic supply, pass-through will be determined jointly by the markdown and the supply elasticity.

increase in the wholesale price w, we apply Leibniz's rule to obtain

$$\frac{dW^{ILT}}{dw} = G(q^*)E[q|q < q^*]\frac{1}{\mu} + (1 - G(q^*))E[q|q \geq q^*]\frac{(1+r)(1-\gamma)}{\mu}$$
$$- \left(\lambda c - (1+r)\gamma\frac{w}{\mu}\right) q^* g(q^*)\frac{dq^*}{dw} \tag{3.17}$$

Intuitively, the change in welfare is the sum of three terms: a) the average change in welfare for farmers on the spot market, weighted by the share of farmers on the spot market; b) the average change in welfare for farmers on ILT contracts, weighted by the share of farmers in ILT; c) the change in welfare for farmers that switch into ILT in response to the change in welfare. Notice that $\frac{dq^*}{dw} < 0$, and so the last term is positive.

The difference between (3.17) and (3.15) depends crucially on the quality of contracting institutions and the density of people near the cut off. It is very possible that price pass-through could be very low, and yet the change in farmers' welfare be high. Similarly, the price pass-through alone does not allow one to recover the markdown rate μ.

Quantifying the welfare effects of the experiment is beyond the scope of the paper. One would need farmer-level estimates of the degree of farmer liquidity constraints in production, of the marginal utility of consumption across different seasons, and of the cost of default on loan contracts. The goal of the simple analyis we presented above is to show that, in the presence of interlinkages, both price and credit response shape how farmer welfare responds to a change in wholesale prices. Propagation of incentives along the value chain is likely to be underestimated when one only focuses on transaction prices. This is particularly relevant in the case of a negative correlation between credit and price responses, which we document in the next section.

3.5 The Substitutability of Price and Credit Pass-Through

We now summarize the core predictions of our model:

1. The share of farmers receiving credit is positively related to the average quantity of cocoa available per farmer in the market, and the number of other traders competing in the market.

2. If $\gamma_m > \hat{\gamma}_2$,

   (a) Across villages, the average transaction price is *negatively* correlated with the share of farmers receiving credit.

(b) The change in transaction price in response to a change in w_m is *lower* in markets in which the extensive margin response of credit supply to the change is larger.

3. If $\hat{\gamma}_3 < \gamma_m < \hat{\gamma}_2$,

   (a) Across villages, the average transaction price is *positively* correlated with the share of farmers receiving credit.

   (b) The change in transaction price in response to a change in w_m is *higher* in markets in which the extensive margin response of credit supply to the change is larger.

Average transaction price could be in principle positively correlated with the prevalence of interlinked transactions if contracting institution quality are low enough that the trader, while still benefiting from the lock-in effect or from the increased quantity, needs to increase the price to avoid farmer strategic default. On the other hand, when contracting institutions are high enough, prices will be negatively correlated with the prevalence of interlinked transactions. Whether the farmer price response to a change in the wholesale price is higher or lower in markets with high credit responsiveness also depends on which of the two cases holds.

We test first prediction 1 and distinguish between 2a and 3a using our baseline data. Table 3.6 presents these results. Each column shows the coefficients from a cross-sectional regression of a village level outcome on other village level covariates and a constant. These indicators come from the pre-treatment period, when our inspectors were collecting data on quantity, prices, and quality of cocoa delivered to wholesalers, but treatments had not been assigned. Column 1 examines first the correlates of credit supply; the outcome here is the village-level share of farmers receiving credit from study traders. This outcome is positively and significantly correlated with the cocoa available per farmer, which is simply the quantity of cocoa delivered from that village in the pre treatment period divided by the number of farmers. This result is consistent with the model's prediction that traders are more likely to extend credit to villages from which they can get higher volumes of cocoa per farmer. In addition, village-level credit share is also positively (and significantly) correlated with the number of traders in the economy. This confirms our intuition about the "lock-in" effect. Controlling for available quantity, credit is more likely to be provided

Table 3.6: *Substitutability, baseline correlations*

Variables	(1) Baseline credit share	(2) Price per lb.	(3) Share of grade A
Pounds of cocoa per farmer	0.09***		
	(0.03)		
Number of study traders	0.03**	-3.8	-0.02*
	(0.01)	(7.6)	(0.01)
Miles to nearest town	0.00	-3.3	0.00
	(0.00)	(2.9)	(0.01)
Baseline credit share		-137.0*	0.34**
		(74.6)	(0.14)
R^2	0.07	0.09	0.11
Number of observations	125	44	75
Dependent variable mean	0.27	3,147	0.29

Notes: An observation is a village. Robust standard errors in parenthesis. The number of observations changes across columns because during the pre-treatment period, price and grade data are available for only the subset of the villages from which cocoa was delivered in that period. In particular, traders brought cocoa bags from only 75 villages and grade A cocoa from only 44 villages during the pre-treatment period. *** p<0.01, ** p<0.05, *p<0.1

in markets with more competition.

Column 2 of Table 3.6 tests directly between predictions 2a and 3a, on the relationship between credit supply and average prices of grade A cocoa. The number of observations here is lower, because the pre-treatment period lasted long enough to observe prices from only a subset of villages. The estimates here show that moving from zero credit share to full credit share decreases the price paid conditional on quality by 137 Leones (s.e. = 74.6). This result suggests that contract enforcement is indeed good enough that traders can pay a lower prices relative to spot markets when entering an interlinked transaction contract (e.g. the condition $\gamma_m > \hat{\gamma}_2$ holds on average). Finally, column 3 shows that the ratio of the volume of high quality cocoa and the total volume of cocoa produced in the village is increasing in the level of credit provision.

We next test between predictions 2b and 3b using variation created by our experiment. We modify equation (3.2) to allow for heterogeneous treatment effects across villages by specifying the regression equation:

$$Credit_{fipv} = \alpha_{ip} + \theta^C(\text{Bonus}_i) + (\text{Bonus}_i \times \mathbf{W}'_v)\boldsymbol{\theta}^C_w + \mathbf{W}'_v\boldsymbol{\beta}_w + (\text{Bonus}_i \times \mathbf{X}'_\mathbf{i})\boldsymbol{\theta}^C_x + \mathbf{X}'_\mathbf{i}\boldsymbol{\beta}_x + {}^\circ\,_{\mathbf{fipv}} \tag{3.18}$$

Table 3.7: *Substitutability of Pass-Through Margin*

Variables	(1) Price	(2) Price	(3) Price
(Bonus $\times$ estimated effect of bonus on credit)	-330.09	-256.49	-182.71
	[.014]	[.006]	[.008]
R^2	0.91	0.91	0.91
Number of observations	1,069	1,069	1,069
Chiefdom fixed effects	YES	YES	YES
Village controls	NO	YES	YES
Trader controls	NO	NO	YES

Notes: Each column presents estimates of θ_c^p from equation 3.19. P-values in brackets are derived from pairs cluster bootstrap-t at the village-level using 1,000 replications. Trader controls are baseline values of pounds of grade A sold, number of villages operating in, number of suppliers buying from, share of clients given credit in baseline, age, years of working with wholesaler, and dummies for ownership of a cement or tile floor, mobile phone and access to a storage facility. Village controls are baseline share of suppliers begin given credit, number of other bonus traders and number of study traders, miles to nearest town, and number of clients across all traders. Trader and village controls are summarized in Tables 3.1 and 3.2, respectively.

where, as before, $\mathbf{W}_v$ is the vector of village covariates and $\mathbf{X}_i$ is a vector of trader level covariates. For any trader-village pair iv then we have an estimator for the credit response $\widehat{TE}_{iv}^c = \mathbf{W}_v'\boldsymbol{\theta}_w^c + \mathbf{X}_i'\boldsymbol{\theta}_i^c + \theta^c$. Finally, we run the following specification to test whether pairs with higher credit pass-through display lower price treatment effect:

$$Price_{kipvt} = \alpha_{ip} + \tau_t + \theta^p(\text{Bonus}_i) + \theta_c^p(\widehat{TE}_{iv}^c \cdot \text{Bonus}_i) + \mathbf{X}_i'\boldsymbol{\beta_x} + \mathbf{W}_v'\boldsymbol{\beta_w} + \epsilon_{kiptv}, \tag{3.19}$$

Substitutability across pass-through margins predicts that $\theta_c^p < 0$.[20]

Table 3.7 presents estimates of θ_c^p. In the different columns we show estimates generated using different sets of controls to predict $\widehat{TE}_{iv}^c$. Any test of significance in equation (3.19) must account for prediction error in the treatment effect on credit. To do so, we follow the recommendations of Bertrand, Duflo, and Mullainathan (2004) and Cameron, Gelbach, and Miller (2008), and present p-values for a Wald test against the null hypothesis that $\theta_c^p = 0$ calculated using the pair cluster

[20]We note that the estimated village-level treatment effect on credit, $\widehat{TE}_{iv}^c$, is collinear with the vector of controls and thus cannot be included in the estimating equation.

bootstrap-t procedure of Efron (1981). Bootstrap clusters are defined at the village level.[21]

Our estimates of θ_c^p are negative and statistically significant at conventional levels in each of the specifications. In column 1, $\widehat{TE}_{iv}^{cN}$ is predicted using only chiefdom dummies. Chiefdoms are local geographic units of legal and political administration, and, as discussed in Acemoglu, Reed and Robinson (2013), a plausible proxy for variation in contract enforcement institutions. The estimate using these dummies predicts that a village where the bonus raised the likelihood of credit provision to farmers by 14 percentage points—the mean treatment effect in Table 3.5—would display a price response 46.2 Leones lower than a village with no effect of the bonus on credit. This is economically relevant as it accounts for a reduction of pass-through by about 1/3 relative to perfect pass-through.[22] We find similar results in column 2, where the effect on credit is predicted using chiefdom dummies and village covariates, and in column 3, where we add trader covariates into the prediction of the credit effect. While the precise magnitude of these results may vary across specifications, the core result is confirmed: price and credit pass-through are substitutes. In villages in which traders respond to a wholesale price increase by raising credit supply to the farmers, price pass-through will be lower.

As we mentioned in Section 3.2.3, one could be concerned about traders misreporting price and credit data. Treatment or control traders may over-report figures in order to continue receiving the bonus or gain access to it, respectively. First, this is unlikely given that traders were informed that the experiment would run for the whole harvest season. Second, the stark difference in measured credit and price treatment effects is not consistent with either of the two misreporting stories. Third, misreporting cannot explain the evidence about the substitutability of the credit and price response margins we presented earlier in this section.

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[21]Specifically, we first estimate $\hat{\theta}_c^p$ on the full sample and generate a T-statistic, T_0 from a Wald test of the null hypothesis that $\theta_c^p = 0$. We then draw with replacement a sample of villages 1,000 times. For each draw, we predict $\widehat{TE}_{iv}^{cN*}$ and then use it to estimate another $\hat{\theta}_c^{p*}$, where the star indicates the bootstrapped sample. We then generate a test statistic T^* from a Wald test of the hypothesis that $\hat{\theta}_c^{p*} = \hat{\theta}_c^p$ using the standard error from the bootstrap estimate. We hold this test statistic in memory. After 1,000 draws, a p-value is calculated from (twice the) position of T_0 in distribution of test statistics T^*.

[22]Recall that perfect pass-through of the bonus would imply pass-through of 150.

3.6 Concluding Remarks

The theory and evidence presented in this paper show that, in the presence of interlinked transactions, low price pass-through may obscure other channels, in particular credit, through which value is passed from buyers to producers. The presence of interlinked transactions is thus a candidate explanation for the low rates of price pass-through that have been observed elsewhere in developing economies, and in a wide variety of other contexts. Further, we show that an industry in which agents in the supply chain play an important role in providing credit, credit supply can be highly responsive to product market conditions.

These results have broad implications. Interlinked transactions along the value chain are common in developing economies and we expect our results to be particularly valuable in these settings. More broadly, interlinkages play a role in a wide range of transactions. For instance, trade credit is a major source of finance for firms internationally (Petersen and Rajan, 1997; Fisman and Love, 2003) and cash-in-advance plays an important role in international trade contracts (Antràs and Foley, 2011). Our work shows that measuring the adjustment along the margin of finance provision will be important for understanding both how incentives are transmitted along the supply chain in these contexts, and how welfare is split between producers and traders.

In addition, the paper leaves several other questions open for further research. In particular, the question of how changes in credit supply driven by the product market conditions faced by intermediaries affects production decisions, particularly in agriculture, is an exciting one for future research. Results there would have important implications for policy makers interested in improving farmers' welfare and overall surplus, and help to better understand the trade-off between policies aimed at reducing markdowns charged by traders, and those aimed at improving the enforcement of contracts.

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Appendix A

Appendix to Chapter 1

A.1 Chiefdom dataset

Table A.1 presents our basic dataset for each chiefdom, organized by district.

A.2 An alternative measure of the concentration of power

Table A.2 presents results from a specification identical to the one presented in Table 1.2 of the paper using an alternative measure of the concentration of power. This measure is the number of times the family that has held the paramount chieftaincy most has done so (i.e., the maximum of the number of times any family has held the chieftaincy). The mean of this variable is 3.5. The results are very similar to those using the Herfindahl index.

Table A.1: *Chiefdom dataset*

District	Chiefdom	Number of ruling families	Amalgamation	Number of seats observed	1900 tax assessment per 1000 people in 1963 census (Pounds sterling)	Km. to 1895 trade route	Herfindahl index of power concentration	2004 literacy rate
Bo	Badjia	2	0	6		18.39	0.56	0.33
	Bagbo	4	0	6		15.30	0.39	0.36
	Bagbwe	4	0	4		16.62	0.63	0.21
	Baoma	2	0	7		0.82	0.51	0.33
	Bumpe Ngao	5	0	3		12.52	0.33	0.33
	Gbo	3	0	6		10.00	0.50	0.28
	Jaiama Bongor	7	1	1	10.01	8.81	1.00	0.33
	Kakua	7	0	9		6.24	0.28	0.47
	Komboya	3	0	7		29.17	0.39	0.25
	Lugbu	2	0	6		8.99	0.72	0.37
	Niawa Lenga	5	0	4		23.04	0.38	0.28
	Selenga	2	0	7		20.80	0.51	0.29
	Tikonko	4	0	3		1.96	0.33	0.35
	Valunia	5	1	6	7.97	6.84	0.33	0.28
	Wonde	3	0	7		2.69	0.35	0.32
Bombali	Biriwa	3	0	6	7.47	1.85	0.50	0.28
	Bombali Sebora	4	1	10	101.34	0.00	0.28	0.38
	Gbanti Kamaranka	5	1	4		9.61	0.38	0.31
	Gbendembu Ngowahun	4	1	1		14.52	1.00	0.28

Table A.1: *Chiefdom dataset (continued)*

District	Chiefdom	Number of ruling families	Amalgamation	Number of seats observed	1900 tax assessment per 1000 people in 1963 census (Pounds sterling)	Km. to 1895 trade route	Herfindahl index of power concentration	2004 literacy rate
	Libeisaygahun	5	1	5		16.73	0.52	0.23
	Magbaimba Ndorhahun	5	1	8		15.60	0.47	0.22
	Makari Gbanti	8	1	2		5.37	0.50	0.31
	Paki Masabong	7	1	3	42.34	13.71	0.33	0.26
	Safroko Limba	2	0	4		7.13	1.00	0.25
	Sanda Loko	5	0	10		22.39	0.26	0.28
	Sanda Tendaran	3	0	7	76.94	13.61	0.59	0.38
	Sella Limba	4	0	8	25.94	9.04	0.28	0.32
	Tambakha	9	1	3	45.65	10.53	0.56	0.19
Bonthe	Bendu-Cha	5	1	3		8.30	0.33	0.33
	Bum	3	0	7	40.02	5.53	0.43	0.25
	Dema	2	0	4	188.15	18.88	0.50	0.15
	Imperri	2	0	4	121.13	14.57	0.50	0.45
	Jong	3	0	6	25.77	19.87	0.39	0.41
	Kpanda Kemo	3	1	7		1.75	0.39	0.29
	Kwamebai Krim	4	1	4	37.83	5.11	0.50	0.18
	Nongoba	3	0	4	12.75	0.51	0.50	0.20
	Sittia	3	0	4		12.68	0.63	0.10
	Sogbeni	2	0	6		6.01	0.56	0.31

Table A.1: *Chiefdom dataset (continued)*

District	Chiefdom	Number of ruling families	Amalgamation	Number of seats observed	1900 tax assessment per 1000 people in 1963 census (Pounds sterling)	Km. to 1895 trade route	Herfindahl index of power concentration	2004 literacy rate
	Yawbeko	4	1	2		8.93	0.50	0.28
Kailahun	Dea	2	0	5		39.33	1.00	0.33
	Jawie	2	0	7	26.70	12.86	0.51	0.32
	Kissi Kama	2	0	6		92.22	0.56	0.37
	Kissi Teng	2	0	7		94.87	0.51	0.41
	Kissi Tongi	4	0	8		86.58	0.28	0.28
	Kpeje Bongre	7	1	3	11.58	45.45	0.56	0.38
	Kpeje West	1	0	5	11.58	46.94	1.00	0.43
	Luawa	3	0	9	5.72	66.05	0.43	0.37
	Malema	3	0	3		21.85	0.56	0.31
	Mandu	1	0	5		32.14	1.00	0.34
	Njaluahun	5	0	7		24.69	0.43	0.40
	Penguia	3	0	9		69.21	0.65	0.36
	Upper Bambara	4	0	9	29.84	46.36	0.33	0.37
	Yawei	4	0	8		61.40	0.25	0.35
Kambia	Bramaia	5	1	4	16.22	28.32	0.38	0.32
	Gbinle Dixin	9	1	4	33.42	38.69	0.25	0.29
	Mabolo	5	0	6	9.57	25.18	0.22	0.38
	Magbema	5	0	9	20.22	27.11	0.23	0.35

Table A.1: *Chiefdom dataset (continued)*

District	Chiefdom	Number of ruling families	Amalgamation	Number of seats observed	1900 tax assessment per 1000 people in 1963 census (Pounds sterling)	Km. to 1895 trade route	Herfindahl index of power concentration	2004 literacy rate
	Masungbala	8	1	8	23.12	19.60	0.34	0.25
	Samu	4	0	11	8.73	42.44	0.32	0.28
	Tonko Limba	4	0	11	15.23	19.98	0.27	0.33
Kenema	Dama	4	0	9	6.01	10.16	0.31	0.26
	Dodo	2	0	7		39.65	0.59	0.22
	Gaura	5	0	8		2.97	0.25	0.20
	Gorama Mende	2	0	6		26.33	0.72	0.22
	Kandu Leppiama	5	1	3	13.13	19.73	0.56	0.35
	Koya	3	0	8	41.07	4.19	0.47	0.21
	Langrama	2	0	4		9.31	0.63	0.29
	Lower Bambara	2	0	10	23.75	49.02	0.50	0.31
	Malegohun	9	1	4	7.87	49.40	0.50	0.27
	Niawa	5	0	5	15.57	8.90	0.44	0.33
	Nomo	2	0	4	27.20	20.06	0.63	0.24
	Nongowa	4	0	9	14.36	25.47	0.31	0.39
	Simbaru	1	0	6	10.36	33.00	1.00	0.30
	Small Bo	3	0	9		12.75	0.51	0.30
	Tunkia	3	0	3	17.77	5.21	1.00	0.21

Table A.1: *Chiefdom dataset (continued)*

District	Chiefdom	Number of ruling families	Amalgamation	Number of seats observed	1900 tax assessment per 1000 people in 1963 census (Pounds sterling)	Km. to 1895 trade route	Herfindahl index of power concentration	2004 literacy rate
	Wandor	3	0	5	6.83	42.00	0.44	0.24
Koinadugu	Diang	2	0	5		23.69	0.52	0.19
	Folosaba Dembelia	4	1	5	17.26	8.12	1.00	0.25
	Kasunko	5	1	5	12.26	12.40	0.52	0.18
	Mongo	6	1	6	24.53	46.03	0.39	0.18
	Neya	4	1	3	25.71	40.35	0.56	0.11
	Nieni	5	1	2	19.62	29.79	0.50	0.20
	Sengbe	3	1	3	30.54	2.71	1.00	0.27
	Sinkunia	2	0	9	18.34	2.59	0.80	0.29
	Sulima	4	1	2	22.44	6.44	1.00	0.19
	Wara Wara Bafodia	7	1	6	25.10	8.30	0.50	0.26
	Wara Wara Yagala	2	0	6	5.69	6.22	0.50	0.39
Kono	Gbense	4	0	7		30.81	0.55	0.43
	Fiama	3	0	6		43.76	0.39	0.36
	Gbane	2	0	7		56.37	0.59	0.33
	Gbane Kandor	1	0	5		69.53	1.00	0.30
	Gorama Kono	2	0	4		50.08	0.50	0.35
	Kamara	4	0	4	3.20	22.60	0.38	0.48
	Lei	1	0	4		52.30	1.00	0.23

Table A.1: *Chiefdom dataset (continued)*

District	Chiefdom	Number of ruling families	Amalgamation	Number of seats observed	1900 tax assessment per 1000 people in 1963 census (Pounds sterling)	Km. to 1895 trade route	Herfindahl index of power concentration	2004 literacy rate
	Mafindor	2	0	6		74.11	0.72	0.24
	Nimikoro	2	0	4	5.51	32.88	0.50	0.46
	Nimiyama	3	0	3		24.96	1.00	0.41
	Sandor	1	0	5	17.03	8.60	1.00	0.25
	Soa	2	0	7	9.63	60.26	0.59	0.27
	Tankoro	3	0	6		42.04	0.39	0.48
	Toli	2	0	5		58.63	1.00	0.24
Moyamba	Bahruwa	4	1	4	42.59	27.65	0.38	0.40
	Bumpeh	2	0	10	35.15	9.58	1.00	0.32
	Dasse	2	0	4		20.50	1.00	0.34
	Fakunya	4	1	3		3.33	0.56	0.40
	Kagboro	2	0	17	54.00	27.15	1.00	0.28
	Kaiyamba	6	0	8		6.47	0.28	0.50
	Kamajei	8	1	3	134.73	7.22	0.33	0.36
	Kongbora	2	0	10		1.80	0.58	0.36
	Kori	4	0	6		0.77	0.56	0.41
	Kowa	6	0	10		12.15	0.30	0.43
	Lower Banta (Gbangbatoke)	5	0	6		36.86	0.72	0.36
	Ribbi	2	0	8	33.45	5.53	0.78	0.28

Table A.1: *Chiefdom dataset (continued)*

District	Chiefdom	Number of ruling families	Amalgamation	Number of seats observed	1900 tax assessment per 1000 people in 1963 census (Pounds sterling)	Km. to 1895 trade route	Herfindahl index of power concentration	2004 literacy rate
	Timbale	2	0	5	76.31	12.74	0.52	0.28
	Upper Banta (Mokele)	3	0	5		20.53	1.00	0.36
Port Loko	Bureh Kasseh Makonteh (BKM)	12	1	3	30.69	9.38	0.56	0.32
	Buya	9	1	3	28.27	1.75	0.56	0.28
	Dibia	4	0	7		5.33	0.31	0.31
	Kaffu Bullom	6	0	10	21.42	8.93	0.20	0.41
	Koya	6	0	10	45.13	11.39	0.20	0.28
	Lokomasama	3	0	9	14.06	17.28	0.41	0.29
	Maforki	11	1	5	16.05	4.13	0.52	0.33
	Marampa	6	0	6	17.00	3.02	0.28	0.44
	Masimera	4	0	6	12.25	8.35	0.28	0.25
	Sanda Magbolontor	4	0	8		3.97	0.41	0.26
	Tinkatupa Maka Saffroko (TMS)	7	1	5	13.03	5.84	0.28	0.23
Pujehun	Barri	9	0	10	26.90	7.69	0.26	0.31
	Galliness Perri	3	1	1	35.40	6.83	1.00	0.29
	Kpaka	1	0	8		10.83	1.00	0.29
	Makpele	5	0	8		14.23	0.53	0.29
	Malen	4	0	4	47.81	10.54	0.63	0.26
	Mono Sakrim	1	0	7	32.04	2.98	1.00	0.19

Table A.1: *Chiefdom dataset (continued)*

District	Chiefdom	Number of ruling families	Amalgamation	Number of seats observed	1900 tax assessment per 1000 people in 1963 census (Pounds sterling)	Km. to 1895 trade route	Herfindahl index of power concentration	2004 literacy rate
	Panga Kabonde	5	1	3	10.18	1.66	0.56	0.32
	Panga Krim	2	0	6	21.58	1.89	0.56	0.36
	Pejeh (Futa Pejeh)	5	0	9	19.82	2.93	0.33	0.32
	Soro Gbema	4	1	3	9.83	5.00	0.33	0.27
	Sowa	1	0	5	67.65	0.71	1.00	0.35
	Yakemu Kpukumu Krim	3	1	3	19.94	0.83	0.56	0.26
Tonkolili	Gbonkolenken	4	1	3	10.90	18.22	0.56	0.28
	Kafe Simiria	3	1	1	15.00	23.64	1.00	0.18
	Kalansogoia	2	1	3	8.04	19.83	0.56	0.17
	Kholifa Mabang	5	0	10	18.11	8.34	0.24	0.31
	Kholifa Rowala	8	1	3	15.12	1.30	0.56	0.40
	Kunike	3	1	4	5.95	1.44	0.38	0.24
	Kunike Barina	4	0	5	9.32	6.49	0.36	0.28
	Malal Mara	8	1	2	11.87	0.16	0.50	0.27
	Sambaya	2	0	9		31.38	0.80	0.14
	Tane	4	0	9	21.81	1.69	0.33	0.25
	Yoni	8	1	4	12.91	20.70	0.38	0.32

Table A.2: *An alternative measure of the concentration of power.*

	(1)	(2)	(3)	(4)	(5)
Dependent variable	Number of seats held by family with most seats				
# of ruling families	-0.32				0.27
	(0.06)				(0.10)
ln(# of ruling families)		-1.39	-1.66	-1.66	-2.62
		(0.22)	(0.23)	(0.24)	(0.44)
Amalgamation			1.26	1.22	1.11
			(0.42)	(0.43)	(0.42)
Number of chiefs recalled		0.51	0.51	0.51	
			(0.09)	(0.08)	(0.08)
F	30.11	40.98			
R^2	0.16	0.20	0.62	0.62	0.63
Observations	149	149	149	149	149
District fixed effects	NO	NO	YES	YES	YES
Geographic controls	NO	NO	NO	YES	YES

Notes: Robust standard errors in parentheses. The number of seats held by the family with the most seats has mean 3.5 (s.d. = 1.5). Geographic controls are a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown.

A.3 Magnitude of potential bias

In column 10 of Table 1.3 in the paper, we conducted an exercise to estimate the magnitude of any bias that might arise from a correlation between the number of ruling families and exogenous determinants of development at the beginning of the 20th century. In this exercise, we generate a prediction for an outcome using district fixed effects and six geographic correlates of development at the turn of the century: distance to prominent trade routes in 1895, distance to coast, distance to 3 major towns, rivers and the railroad, and a dummy for the presence of mining permissions in the 1930s. Regressing this prediction on the log number of ruling families allows us to assess the correlation between the log number of ruling families and the exogenous component of the outcome, and provides an estimate of the magnitude of any omitted variable bias that might arise from this correlation.

Table 1.3 presented this exercise for literacy; in Table A.3, we do this for an additional set of variables. As in Table 1.3, standard errors in these columns have been block bootstrapped at the chiefdom level to account for sampling error in the prediction of the outcome from the covariates;

Table A.3: *Estimates of magnitude of potential omitted variable bias*

Predicted variable	(1) Respect authority	(2) Bridging capital index	(3) Bonding capital index	(4) Collective action index
ln(# ruling families)	0.000	-0.005	0.001	-0.001
	(0.009)	(0.007)	(0.003)	(0.006)
R-squared	0.960	0.948	0.962	0.990
Observations	149	149	149	149
District FE	YES	YES	YES	YES

Outcome variables are predictions of the outcome using five correlates of development at the turn of the century: a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown. Standard errors in parenthesis have been block bootstrapped at the chiefdom level to account for sampling error in the prediction; the prediction was estimated 500 times, drawing with replacement a sample of chiefdoms and all observations within them.

predicted literacy was estimated 500 times, drawing with replacement a sample of chiefdoms and all observations within them.

In column 1 of Table A.3, for whether the individual respects authority, the effect of the log number of ruling families is equal to 0.000, far from the effect of -0.084 we estimate in column 2 of Table 1.8. Though the confidence interval does admit larger bias, even the lower bound of a 95% confidence interval admits only an effect of -0.018, less than 1/4 of the effect found in Table 1.8. Similarly, in columns 2-4, the bias is very small—in particular, much smaller than the effects shown in Table 1.9.

Overall, these results suggest that although we cannot rule out some amount of omitted bias in our estimates, this bias could not be large enough to explain the effects we observe.

A.4 Literacy over time

Table A.4 reports the coefficients plotted in Figure 1.6.2 of the paper. While individual level data are available from the 2004 census, only chiefdom cohort aggregates are available from the 1963 census. For consistency in this table and in Figure 4 we present results for cohorts observed in the 2004 census using aggregates as well. In addition, while in Table 1.4 individuals observed in the

2004 census are matched to chiefdoms based on chiefdom of birth, individuals in these tables are matched based on chiefdom of residence to ensure consistency with the 1963 census, which does not report education by chiefdom of birth.

Table A.4: *Effects on literacy by birth cohort*

Birth Cohort	Pre 1918	1919-1923	1924-1928	1929-1933	1934-1938	1939-1943	1944-1948
ln(# ruling families)	0.002	0.006	0.009	0.005	0.009	0.010	0.015
	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.008)
R^2	0.29	0.23	0.28	0.24	0.27	0.28	0.41
Observations	148	148	148	148	148	148	148
Birth Cohort	1949-1953	1954-1958	1959-1963	1964-1968	1969-1973	1974-1978	1979-1983
ln(# ruling families)	0.031	0.034	0.041	0.036	0.040	0.037	0.046
	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)	(0.013)	(0.017)
R^2	0.45	0.28	0.35	0.31	0.28	0.26	0.26
Observations	148	149	149	149	149	149	149

Notes: Robust standard errors in parenthesis. The table presents coefficients in the OLS regression of the chiefdom literacy rate among five-year birth cohorts on the log number of families. All specifications include number of chiefs recalled, an amalgamation dummy and district fixed effects. Individuals are matched on chiefdom of current residence; chiefdom of birth is not available in the 1963 census. Cohorts born before 1953 are observed in the 1963 census, in which one chiefdom, Dibia, has missing data. Only chiefdom level aggregates were available in the 1963 census. For continuity, we present results for cohorts observed in the 2004 census using aggregates as well.

A.5 Components of asset wealth, housing quality and social capital indicies

Here we present results for the individual outcomes comprising our mean effects indicies for asset wealth, housing quality and social capital. In Table A.5, we present the constituents of our asset wealth index in columns 1-7, and the constituents of our housing quality index in columns 8-10. Though all are not significant, all are positive, and we are reassured that the few with particular salience in Sierra Leone, such as ownership of mobile phone, an umbrella and a radio, are significant and positive. Table A.6 includes the social capital measures, in addition to a few measures of trust.

Finally, Panel A of Table A.7 reports the correlations between our three indices and a few variables of particular interest. This table confirms that the three indices are only weakly correlated, and so capture different aspects of social capital. Panel B of Table A.7 reports the correlations of chiefdom level averages of these variables with various development outcomes, showing that in our sample, development outcomes and measured social capital are generally weakly or negatively correlated.

Table A.5: *Individual asset results (NPS)*

Asset	(1) Bicycle	(2) Generator	(3) Mobile phone	(4) Car, truck or motor-cycle	(5) Electric fan	(6) Radio	(7) Umbrella	(8) TV	(9) Cement or tile floor	(10) Cement wall	(11) Zinc or tile roof
ln(# of ruling families)	0.001	0.011	0.068	0.006	0.020	0.051	0.046	0.020	0.078	0.043	0.051
	(0.011)	(0.008)	(0.025)	(0.005)	(0.008)	(0.023)	(0.021)	(0.008)	(0.026)	(0.022)	(0.031)
R^2	0.027	0.026	0.059	0.011	0.028	0.050	0.036	0.024	0.058	0.041	0.105
Observations	5,072	5,074	5,071	5,072	5,074	5,070	5,077	5,072	5,077	5,077	5,077
District fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Demographic controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. Dependent variables are all dummy variables $\in \{0, 1\}$. All specifications include 12 district fixed effects, number of seats and an amalgamation dummy. Demographic controls are gender, age, age squared, and ethnicity dummies for the household head.

Table A.6: *Individual measures of social capital (NPS)*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Bonding social capital index									
Dependent variable	Savings or or credit group	Labor gang	Secret society	Trade union	Political group	Women's group	Youth group	Farmer's group	Religious group	School group
ln(# of ruling families)	-0.033	-0.069	-0.051	0.003	-0.009	-0.047	0.002	-0.077	-0.020	-0.023
	(0.015)	(0.022)	(0.026)	(0.005)	(0.011)	(0.014)	(0.016)	(0.024)	(0.019)	(0.017)
R^2	0.041	0.083	0.072	0.008	0.056	0.209	0.166	0.074	0.079	0.069
Observations	5,056	5,060	5,050	5,051	5,055	4,953	4,283	4,901	5,063	5,056
	Bridging social capital index			*Collective action index*		*Trust in others*		*Trust in chiefs*		
Dependent variable	Comm-unity meeting	Local council meeting	Meeting with chief	Road brushing	Comm-unal labor	Trust people outside locality	Trust people inside locality	Trust chief	Believes chiefs are corrupt	
ln(# of ruling families)	-0.086	-0.054	-0.043	-0.085	-0.052	0.017	0.002	-0.003	0.011	
	(0.024)	(0.018)	(0.026)	(0.028)	(0.017)	(0.025)	(0.024)	(0.023)	(0.020)	
R^2	0.083	0.060	0.087	0.118	0.061	0.023	0.044	0.022	0.081	
Observations	5,035	5,051	4,556	5,049	4,993	5,077	5,077	5,077	5,077	
District fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Demographic controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. Dependent variables are all dummy variables $\in \{0,1\}$. Outcomes in columns 6-8, second row, are affirmative responses to, "in your opinion do you believe [....] or do you have to be careful in dealing with them?" "Believe" is a close translation of the Krio word for trust. The trust outcome in column 9, second row, is the response to the question: "If the Paramount Chief was given 500 million Leones ($125,000) to complete a project in this area, do you believe they would spend all the money doing a good job on the project or would they cut some of the money?" (cut meaning take for their own purposes). The outcome equals one if the chief would either "do a bad job and cut most of the money" or "they would just take all the money."

Table A.7: *Social capital activities, correlation coefficients*

	Bridging capital index	Attended community meeting	Bonding capital index	Savings or credit group member	Labor gang member	Secret society member	Collective action index
	Panel A: Individual level correlations of activities						
Bridging capital index	1.00						
Attended community meeting	0.73	1.00					
Bonding capital index	0.41	0.37	1.00				
Savings or credit group member	0.09	0.08	0.37	1.00			
Labor gang member	0.21	0.23	0.50	0.03	1.00		
Secret society member	0.12	0.10	0.48	0.06	0.15	1.00	
Collective action index	0.38	0.42	0.33	0.13	0.19	0.11	1.00
	Panel B: Chiefdom level correlations of aggregate shares						
Primary school attainment (Census)	-0.09	-0.13	0.01	0.02	-0.36	0.23	-0.02
Non-agricultural employment (Census)	-0.08	-0.11	-0.08	-0.02	0.02	-0.08	-0.35
Asset wealth index (NPS)	-0.23	-0.31	-0.27	0.09	-0.32	-0.16	-0.39
Housing quality index (NPS)	-0.13	-0.08	-0.20	0.08	-0.16	-0.27	-0.25

Notes: Panel A shows raw correlations of variables across individuals. Panel B shows the correlations across chiefdoms chiefdom level averages. Individuals are matched on chiefdom of birth.

Table A.8: *The number of ruling families and rice ecology.*

Dependent Variable	(1) Plot is lowland	(2) Share of rice acreage lowland
Ln(# of ruling families)	-0.009	0.008
	(0.028)	(0.032)
Amalgamation	-0.013	0.004
	(0.040)	(0.046)
Number of chiefs recalled	0.009	0.005
	(0.006)	(0.007)
R^2	0.053	0.430
Number of observations	9,664	142
District Fixed Effects	YES	YES
Outcome mean	0.466	0.37
Outcome s.d.	0.499	0.214

Notes: Robust standard errors clustered at the chiefdom level are reported in parenthesis. The outcome in column 1 is a dummy for whether a plot owned by the household is of the higher productivity "lowland" variety, either inland valley swamp, boli land, mangrove swamp or riverrine area. The outcome in column 2 is the share of total acreage owned by households in the chiefdom that is lowland.

A.6 The number of ruling families and rice ecologies

Rice farming in Sierra Leone is done on two types of land, lowland and upland. Lowland is broken into four categories: inland valley swamp, mangrove swamp, boli land, and riverrine area. In Table 1.7, we included dummies for each of these types of land as controls.

The distinction between lowland and upland is most relevant for productivity. In Table A.8 we relate measures of the abundance of lowland land in a chiefdom to the log number of ruling families, and find no relationship. In column 1 we test for whether the log number of ruling families makes a household more or less likely to have a plot that is lowland. The estimated effect here is small and insignificant. In column 2 we test for whether the share of rice acreage that is lowland is different in chiefdoms with more families. Acreage shares were calculated by summing the area of all plots owned by households. We find an effect very close to zero.

A.7 Placebo tests

Given the modest size of the sample of chiefdoms in our datasets (149 in the census and NPS; 117 in the DHS) it is helpful to assess whether our results are still statistically significant under permutation-based p-values which do not rely on large sample asymptotics. To do this, we implement a Monte Carlo exercise using the data from the NPS and DHS household surveys in which we allocate placebo numbers of ruling families to chiefdoms. Placebos are drawn randomly from the empirical distribution of the number of ruling families. For each outcome, we calculate a p-value by comparing the estimated effect of the log placebo number of ruling families to the estimate calculated using the true data.

Formally, we undertake the following procedure K times. For each chiefdom, we draw randomly with replacement from the empirical distribution of the number of ruling families to obtain a placebo number of ruling families for that chiefdom. We do this for each chiefdom within each simulation $k \in \{1, K\}$. Next, for each k, we regress the outcome on the placebo log number of ruling families to obtain a placebo effect. The regression is identical to our core specification using district fixed effects, demographic controls and the amalgamation dummy and number of chiefs observed. The position of the true estimate of the effect in the distribution of placebo effects provides us with a p-value indicating the likelihood that our results are consistent with the null hypothesis.

Figure A.1 presents histograms of these distributions for $K = 1,000$ using six of our key binary outcomes. P-values are reported below each plot. For each outcome, the placebo effects are centered around zero, approximating well the null hypothesis. In all cases, we can reject the null hypothesis that the effect of the log number of ruling families is zero in a two-sided test with a significance level of 95%.

A.8 Outcomes matched on chiefdom of residence, outcomes for those residing in the chiefdom in which they were born.

In the paper, we conducted most of our analysis matching individuals on chiefdom of birth rather than residence. Table A.9 shows that our results are robust to matching on residence. In column

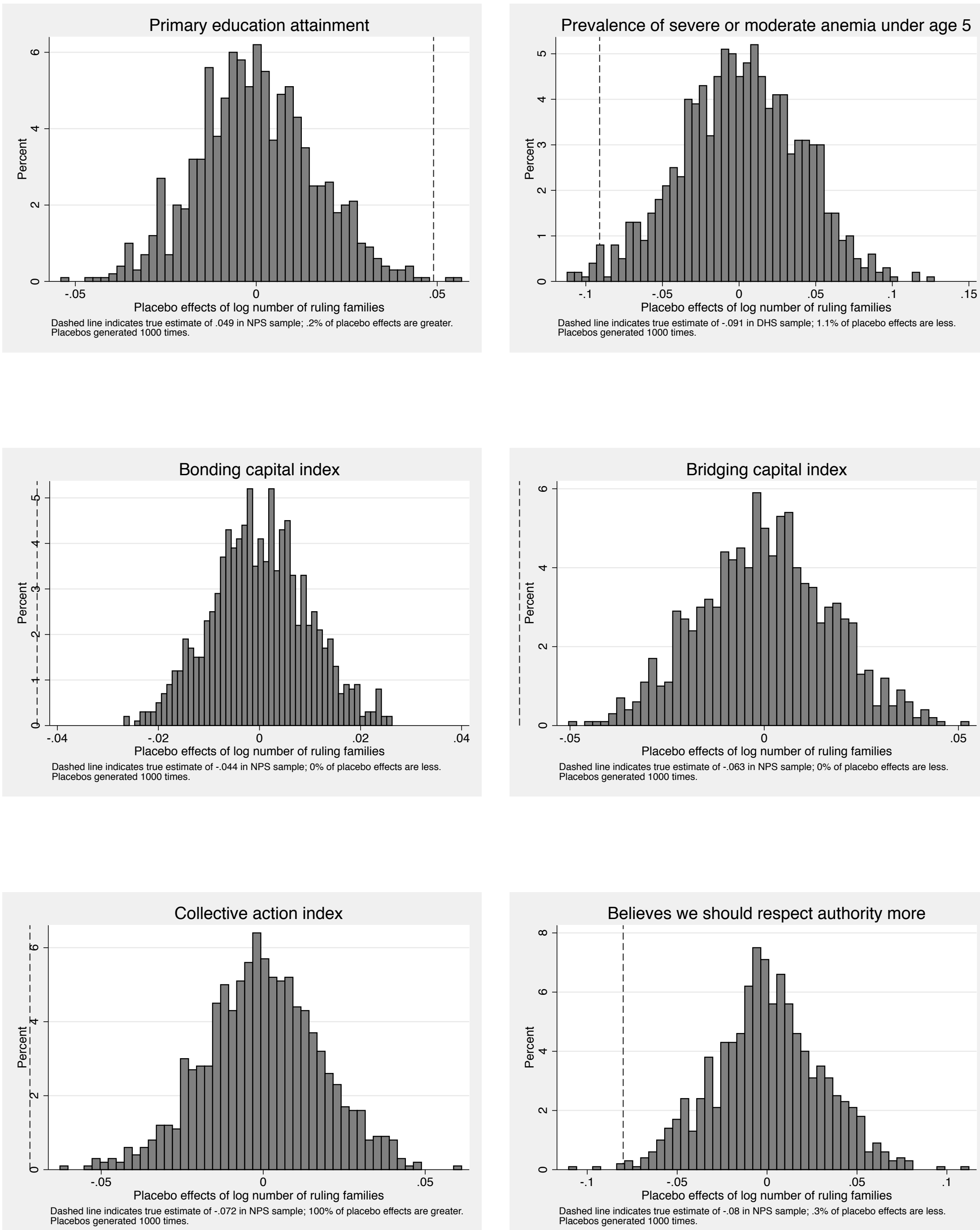

Figure A.1: *Permutation based p-values for NPS and DHS data*

1, we match on chiefdom of birth and show that individuals from chiefdoms with more ruling families are significantly more likely to have moved to an urban area outside of the chiefdom. This is consistent with returns to education being higher in urban areas. The rest of the columns show our key outcomes matching individuals on chiefdom of residence instead of chiefdom of birth, testing only for differences between those remaining. Broadly, the results are very similar in significance and magnitude.

We also consider the possibility that our social capital results may be driven by migration. This might be for two distinct reasons. Either individuals have moved from chiefdoms with high numbers of families to cities where they choose not to participate in the social capital activities, or individuals who dislike participating in social capital activities leave chiefdoms with small numbers of families for chiefdoms with higher numbers. In Table A.10, we test whether these stories are driving our result by replicating our results on the subsample of the population living in the chiefdom in which they were born. The coefficients are similar to those in Tables 1.8 and 1.9 of the paper, retaining both their magnitudes and significance. These results reject the hypothesis that our results are explained primarily by either of the stories above.

Table A.9: *Outcomes matched on chiefdom of current residence*

Dependent variable	(1) Resides in urban area outside chiefdoms	(2) Non-ag. employ-ment	(3) Literacy	(4) Agree one should respect authority	(5) Bridging capital index	(6) Bonding capital index	(7) Collective action index
	Panel A: Baseline specification						
ln(# of ruling families)	0.031	0.022	0.045	-0.080	-0.066	-0.044	-0.067
	(0.016)	(0.011)	(0.011)	(0.040)	(0.018)	(0.009)	(0.027)
R^2	0.038	0.033	0.135	0.067	0.136	0.118	0.151
	Panel B: Baseline specification with additional geographic controls						
ln(# of ruling families)	0.026	0.014	0.032	-0.083	-0.060	-0.044	-0.080
	(0.014)	(0.011)	(0.010)	(0.040)	(0.019)	(0.009)	(0.028)
R^2	0.042	0.037	0.137	0.070	0.139	0.120	0.154
Observations	2,622,861	2,288,874	2,148,914	4,391	4,275	3,485	4,296
District fixed effects	YES	YES	YES	YES	YES	YES	YES
Demographic controls	YES	YES	YES	YES	YES	YES	YES

Notes: Standard errors in parenthesis are robust to heteroskedasticity and clustered at the chiefdom level. All outcomes are matched on chiefdom of residence except in column 1 in which individuals are matched on chiefdom of birth. Urban area outside chiefdom indicates an area such as Bo or Kenema, administered by a town local council and not a Paramount chief or anywhere in the urban and peri-urban Western peninsula where the capital Freetown is located. Specifications in Panel B include six additional geographic controls: a dummy for the presence of mining permissions in the 1930s, distance to coast, distance to nearest river, distance to 1895 trade routes, distance to 1907 railroad, and minimum distance to Bo, Kenema or Freetown.

Table A.10: *Social outcomes for those living in the chiefdom in which they were born*

Dependent variable	(1) Bridging social capital index	(2) Bonding social capital index	(3) Collective action index	(4) Agree one should respect authority	(5) Agree only older people can lead
ln(# of ruling families)	-0.060	-0.043	-0.067	-0.086	-0.050
	(0.021)	(0.010)	(0.027)	(0.040)	(0.028)
Amalgamation	0.009	0.032	0.047	0.074	0.008
	(0.036)	(0.016)	(0.033)	(0.049)	(0.043)
Number of chiefs recalled	-0.000	0.003	0.002	0.013	0.009
	(0.005)	(0.002)	(0.004)	(0.007)	(0.006)
R^2	0.138	0.122	0.152	0.070	0.070
Observations	3,466	2,825	3,488	3,565	3,565
District Fixed Effects	YES	YES	YES	YES	YES
Demographic controls	YES	YES	YES	YES	YES

Notes: Robust standard errors clustered at the chiefdom level are in parenthesis. The sample comprises individuals who live in the chiefdom in which they were born.

A.9 Robustness to researcher fixed effects and illegitimate ruling families.

Our key measure of the number of ruling families was collected by a team of eight field researchers who conducted interviews with elders in all chiefdoms. A concern is that the results obtained our paper could be due to a bias of researchers that caused them to count more families in more developed chiefdoms. While we believe this is unlikely given the training given to researchers, in this section we provide a test of this hypothesis. Researchers were rotated between teams over the course of the project. In Table A.11, we present results for some of our outcomes in regressions that include fixed effects for each of the researchers. While this cannot rule out a systematic and equal bias on the part of all researchers, adding these fixed effects will change our estimates if there is a strong bias on the part of some particular researchers. That the coefficients reported in Table A.11 differ little from those presented in the paper suggests that this is not the case.

A total of seven chiefdoms had new families installed by politicians after independence: Biriwa, Neya, Kaffu Bullom, Koya (Port Loko), Kalansogoia, Neini, Mandu. Since the civil war, none of these families have been viewed as legitimate or permitted to stand in elections. Table A.12 shows our core results estimated in the NPS data with a number of ruling families that includes these illegitimate families. Broadly, their inclusion does not affect our results.

Table A.11: *Results with researcher fixed effects*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable	Literacy	Primary	Secondary	Non-ag. employ.	Respects authority	Weight-for-height Z-score	Asset wealth index
Data source	Census	Census	Census	Census	NPS	DHS	NPS
ln(# of ruling families)	0.045	0.049	0.036	0.015	-0.067	0.248	0.053
	(0.011)	(0.013)	(0.009)	(0.007)	(0.027)	(0.108)	(0.022)
Variable	Bridging capital index	Attended community meeting	Bonding capital index	Savings and credit group member	Labor gang member	Secret society member	Collective action index
Data source	NPS	NPS	NPS	NPS	NPS	NPS	NPS
ln(# families)	-0.060	-0.078	-0.038	-0.036	-0.066	-0.044	-0.060
	(0.017)	(0.022)	(0.008)	(0.016)	(0.019)	(0.024)	(0.018)

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. Specifications are identical to those used in paper in tables 4, 5, 6, 8 and 10 that include district fixed effects, controls for the number of families observed and amalgamation and demographic controls.

Table A.12: *Results with illegitimate families included*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables	Primary school attainment	Asset wealth index	Housing quality index	Agree one should resp. authority	Bridging capital index	Bonding capital index	Collective action index
ln(# of ruling families)	0.049	0.026	0.053	-0.088	-0.064	-0.038	-0.069
	(0.025)	(0.010)	(0.023)	(0.028)	(0.019)	(0.008)	(0.020)
Amalgamation	0.034	-0.021	-0.018	0.074	0.003	0.031	0.048
	(0.045)	(0.017)	(0.034)	(0.036)	(0.028)	(0.012)	(0.024)
Number of chiefs recalled	0.007	0.003	0.011	0.010	-0.005	0.002	0.000
	(0.007)	(0.002)	(0.005)	(0.005)	(0.004)	(0.002)	(0.003)
R^2	0.121	0.063	0.093	0.053	0.126	0.102	0.121
Observations	5,041	5,054	5,077	5,077	4,499	4,070	4,976
District fixed effects	YES	YES	YES	YES	YES	YES	YES
Demographic controls	YES	YES	YES	YES	YES	YES	YES

Notes: The log number of ruling families includes an additional family for Biriwa, Neya, Kaffu Bullom, Koya (Port Loko), Kalansogoia, Neini, Mandu chiefdoms, which had families introduced by political influence after independence that are today viewed as illegitimate. Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. Each specification also includes number of chiefs recalled and an amalgamation dummy. Demographic controls include age, age squared, and gender and ethnicity dummies. Individuals matched on chiefdom of birth.

A.10 Robustness to connections to chieftaincy elite

An alternative explanation for our results could be that the number of ruling families is associated with a broader distribution of patronage within the chiefdom that raises the observed means of our outcomes. Under this hypothesis, it would not be better governance driving the results, but rather a different structure of the patron-client network. The NPS allows us to test this hypothesis directly. It includes three measures of connections to the chieftaincy elite: whether the respondent has a paramount or section chief in the household, whether the respondent is a member of a ruling family, and whether the respondent has village headman in the household. Table A.13 shows that our core results are robust to the inclusion of these controls. As expected, the coefficients on connections to the chieftaincy elite are generally positive (and sometimes statistically significant).[1]

It is also possible that the extent of patronage is related to the number of families on the extensive and/or the intensive margin. On the extensive margin, it could be that in places with more families, there are more people affiliated with the ruling families, each of whom demands a transfer. We provide evidence against this hypothesis in Panel A of Table A.14 , which indicates that there is not more broad-based membership in ruling families or an increased likelihood of having a paramount chief or headman in the household in chieftaincies with more ruling families.

On the intensive margin, it could be that a given elite in a chiefdom with more ruling families demands more patronage, since his vote is now more likely to be pivotal in an election. We investigate this hypothesis in Panel B of Table A.14 , which shows estimates of the following regression,

$$y_{ic} = \beta_c + \beta_{elite} \cdot E_i + \beta_{fam} \cdot (E_i \times F_c) + \mathbf{X}'_{ic} \cdot \mathbf{fi}_X + \varepsilon_{ic}, \tag{A.1}$$

where y_{ic} is a development outcome for individual i in chiefdom c, β_c is a chiefdom fixed effect and E_i is a dummy indicating a connection of individual i to the chieftaincy elite. The coefficient β_{fam} describes how differences in the variable of interest between chiefdom elite and non-elites

[1] The exception is the coefficient for village headman in columns 1, 2, and 3. The negative sign on this coefficient should be interpreted with caution, and cannot be taken to imply that village headman are worse off than the average citizen within the chiefdom. This coefficient describes the effect of being a village headman who is not connected to the chieftaincy elite, either through relation to a more senior chief, or by membership in a ruling family. If we add the partial effects of these other connections, the total effect of being a well-connected headman is statistically indistinguishable from zero. Note also that 58% of households with headmen also include either a ruling family member or a paramount or section chief.

vary with the (log) number of ruling families. The vector $\mathbf{X}'_{ic}$ includes the same individual level socio-demographic covariates as in previous specifications. Here all outcomes are matched on chiefdom of residence. The broadly negative estimates of β_{fam} show that within chiefdoms inequality between elites and non-elites is, if anything, declining with the number of ruling families. This result is inconsistent with a more intensive distribution of patronage driving our results. In fact, the pattern here strengthens our argument as it suggests that, if anything, more competition for the chieftaincy produces more equality (less different outcomes) between elites and non-elites.

Table A.13: *Robustness check including connections to chieftaincy elite*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables	Primary school attainment	Asset wealth index	Housing quality index	Agree one should resp. authority	Bridging capital index	Bonding capital index	Collective action index
ln(# of ruling families)	0.055	0.028	0.064	-0.086	-0.059	-0.036	-0.067
	(0.025)	(0.010)	(0.023)	(0.027)	(0.018)	(0.008)	(0.019)
Paramount or section chief in household	0.012	0.021	0.048	0.014	0.085	0.048	0.053
	(0.025)	(0.013)	(0.022)	(0.031)	(0.024)	(0.013)	(0.022)
Member of ruling family	0.029	0.025	0.027	0.003	0.079	0.021	0.038
	(0.017)	(0.007)	(0.013)	(0.020)	(0.014)	(0.008)	(0.013)
Headman in household	-0.062	-0.032	-0.077	0.015	0.095	0.063	0.081
	(0.020)	(0.007)	(0.015)	(0.025)	(0.019)	(0.009)	(0.017)
R^2	0.125	0.071	0.104	0.070	0.180	0.157	0.171
Observations	4,770	4,780	4,803	4,803	4,252	3,867	4,714
District fixed effects	YES	YES	YES	YES	YES	YES	YES
Demographic controls	YES	YES	YES	YES	YES	YES	YES

Notes: Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. Each specification also includes number of chiefs recalled and an amalgamation dummy. Demographic controls are age, age squared, and gender and ethnicity dummies. Individuals matched on chiefdom of birth.

Table A.14: *Patronage along the extensive and intensive margins*

	(1)	(2)	(3)
Panel A: Extensive margin			
Dependent variable	Member of ruling family	Paramount or section chief in household	Headman in household
ln(# of ruling families)	-0.015	-0.021	-0.013
	(0.025)	(0.013)	(0.018)
R^2	0.259	0.204	0.197
Observations	149	149	149
District fixed effects	YES	YES	YES
Panel B: Intensive margin			
Dependent variable	Primary school attainment	Mobile phone ownership	Has tile or cement floor
Paramount or section chief in household	0.007	0.026	0.090
	(0.041)	(0.042)	(0.049)
Paramount or section chief in household ×	-0.001	0.011	-0.022
ln(# of ruling families)	(0.031)	(0.032)	(0.037)
R^2	0.169	0.128	0.115
Observations	4,353	4,381	4,387
Ruling family member	0.058	0.069	0.047
	(0.039)	(0.026)	(0.034)
Ruling family member ×	-0.032	-0.017	0.003
ln(# of ruling families)	(0.029)	(0.018)	(0.022)
R^2	0.174	0.133	0.121
Observations	4,103	4,128	4,134
Headman in household	0.036	0.050	0.032
	(0.034)	(0.025)	(0.030)
Headman in household ×	-0.039	-0.033	-0.024
ln(# of ruling families)	(0.025)	(0.019)	(0.024)
R^2	0.170	0.127	0.112
Observations	4,349	4,377	4,383

Notes: In panel A, dependent variables are chiefdom shares observed in the NPS, matched on chiefdom of birth. Specifications include district fixed effects and standard errors are robust to heteroskedasticity. In panel B, dependent variables are all dummies matched on chiefdom of residence. Standard errors are robust to heteroskedasticity and clustered at the chiefdom level. Each specification includes chiefdom fixed effects and demographic controls (gender and ethnicity dummies, age and age squared). Specifications in both panels includes the number of chiefs recalled and an amalgamation dummy.

Appendix B

Appendix to Chapter 2

B.1 Proofs of Propositions

Proof of Proposition 1.

We will find the peak of the equilibrium condition and define a the range of parameters under which the peak exists. Preform a change of variable on (2.9) using (2.10). Then take the derivative of the left hand side with respect to $\ln(F_{dt})$ to get

$$\frac{\partial \ln(R_t)}{\partial \ln(F_{dt})} = \left(\frac{\omega_d}{1+\eta+\omega(1+\eta)}\right)\left(\frac{\omega_d - \eta(1+\omega_d)}{\iota\omega_d}\left(\frac{F}{1-F}\right)+1\right) = 0$$

By (2.1) $F_{dt} \in [0,1]$, so the equilibrium allocation for a particular region will be unique if the point at which the peak of the equilibrium condition is at a value of F_{dt} outside of this range. This value of F_{dt} must satisfy

$$\frac{-\omega_d + \eta(1+\omega_d)}{\omega_d \iota} F_{dt} = 1 - F_{dt}$$

Which requires

$$-\omega_d + \eta(1+\omega_d) \geq 0$$
$$\omega_d \leq \frac{\eta}{1-\eta}$$

■

Proof of Proposition 2. The firm faces the constrained maximization problem

$$\max_{K_{dt},L_{dt}} AL_{dt}^{\eta_i}K_{dt}^{1-\eta_i} - W_{dt}L_{dt} - R_tK_{dt} - \lambda(K_{dt} - \bar{K}_{dt})$$

with the Kuhn-Tucker conditions

$$MPK_{dt} = R_t + \lambda, \quad MPL_{dt} = W_{dt} \quad \lambda(K_{dt} - \bar{K}) = 0, \quad K \leq \bar{K}_{dt},$$

where λ is the Lagrangian multiplier, interpreted as a the shadow cost of the constraint. If the constraint is not binding $\lambda = 0$. The first two yield the optimal capital labor ratio

$$\frac{K_{dt}}{L_{dt}} = \frac{W_{dt}}{R_t + \lambda}\left(\frac{1-\eta_i}{\eta_i}\right)$$

Setting $R_t + \lambda = R_t(1 + \tau_{dt})$ as in the paper and applying the definition of λ from the Kuhn Tucker conditions yields

$$\tau_{dt} = \frac{1}{MPK_{dt}}\frac{MPK_{dt} - R_t}{R_t} = \frac{1}{R_t} - \frac{1}{MPK_{dt}}$$

■

Proof of Proposition 3. The spatial equilibrium defines $W_d(\tau_d)$ as an implicit function of the local tax rate on capital available to the government, where industry year subscripts have been dropped for simplicity.

The wage bill maximizing policy is a vector of taxes

$$\boldsymbol{\tau_d} \in \arg\max_{\tau_d} \sum_d L_d \cdot W_d = \arg\max_{\tau_d} \sum_d N_d \cdot (1 - W_d^{-\iota}) \cdot W_d$$

This satisfies the first order condition:

$$N_d(1 - (1-\iota)W_d^{-\iota})\frac{\partial W_d}{\partial \tau_d} = 0 \implies \frac{\partial W_d}{\partial \tau_d} = 0 \tag{B.1}$$

The utility maximizing policy is a vector of taxes

$$\boldsymbol{\tau_d} \in \arg\max_{\tau_d} \sum_d N_d \left(W_d + \frac{1}{\iota - 1}W_d^{1-\iota}\right)$$

This satisfies the first order condition:

$$L_d\frac{\partial W_d}{\partial \tau_d} = 0 \implies \frac{\partial W_d}{\partial \tau_d} = 0 \tag{B.2}$$

which is identical to (B.1).

■

B.2 Data Appendix

The Annual Survey of Industries Manufacturing variables are measured using the unit-level summary data from the Annual Survey of Industries (ASI), accessed through the Harvard University Library. The survey, which is used to construct the national input-output tables and the manufacturing component of national accounts, covers all factories registered under Sections 2m(i) and 2m(ii) of the Factories Act, 1948; e.g. all factories employing 10 or more workers using power, and all those employing 20 or more workers without using power. The sampling frame is based on the lists of registered establishments maintained by the Chief Inspector of Factories in each state.

Location Identifiers District identifiers are provided for survey rounds 1980/81-1994/95.[1] For rounds 1980/81 through 1988/89, these district identifiers correspond to the district codes used in the 1981 census. For rounds 1991/92-1994/95, they correspond to the district codes used in the 1991 census. In the intervening rounds 1989/90-1990/91 other codes were used by survey administrators and a key is unavailable– -presumed lost—so these years are dropped from the analysis.

Numerical codes provided in the ASI data were linked to names of districts using official census documentation. Codes for 1991 were taken from the electronic versions of the census distributed by the Registrar General. Codes for 1981 were transcribed by the author from the tables in "Census of India 1981: Primary Census Abstract, General Population," Series 1-India, Part II B(i), accessed at the NSSO Library, Calcutta, Jan 6, 2012. The number and composition of districts changes over time. Contiguous regions, the unit of observation in this study, were created by aggregating districts across census years following Kumar and Somanathan (2009).

A discussion of this aggregation process as it was applied to the ASI data follows. Between the census years, new districts were created. In the intervening years of the ASI, these appear as new district codes not listed on the preceding census's code sheet. Districts were apportioned to contiguous regions using the following algorithm. The General Population Tables of the censuses

[1]Descriptive analyses using these district identifiers have been conducted by Lall et. al. (2004), and Ghani et. al. (2011).

(Appendix to Table 1A) list all the newly created districts, and the districts from which their land area was taken. Within a state, all the districts from which land is taken are highlighted. If they are all within one contiguous region, all the newly created districts are coded as being in that same contiguous region.

In a small number of states, this is not possible. In some states, many new districts were created, but their land was taken from districts spanning many regions. Aggregating them all would create a contiguous region much larger than the others in the sample. In these cases, the observations could not be assigned a region and were dropped. As a consequence, it might be that some districts will have lost observations to these dropped district. To account for this any district loosing area in these state was also dropped from the aggregate regions. This occurred, for instance, in Bihar. In addition, due some idiosyncrasies in the codes used for parts of Gujarat and Karnataka in the 1990s, some districts in these states could not be linked across years, and so were dropped. Overall, however, the final data set still includes a substantial share of total output in the ASI, across both industries and states.

Regional Aggregates Consistent estimates for region industry variables were constructed using sampling weights ("multipliers") provided with the data.[2] Sampling in the ASI was stratified within state industries. Within each state industry there is a census strata, in which all establishments were surveyed, and sample strata, the number of which vary across years. The census strata included from 1980/81-1986/87 all establishments with 50 or more workers operating with power, all establishments having 100 or more workers operating without power, and all establishments in the states and union territories of Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Nagaland, Tripura and Pondicherry, Andaman and Nicobar Islands, Chandigarh, Goa, Daman and Diu, Dadra and Nagar Haveli; and in later years all establishments having 100 or more workers, with or without power, and those in the states and territories listed above.

The weights were originally constructed in order to estimate state aggregates. Suppressing indicies for states and industries, a consistent estimator for the population total in each state

[2]Discussions with staff at the MOSPI computer center indicate that the data for years 1987/88 and 1988/89 have already been multiplied by their weight, and the weights themselves are not provided.

industry is

$$\hat{\tau} = \sum_s w_s \sum_{i=1}^{n^s} y_{is}$$

where s indexes the strata within each state industry, y_{is} is an observation of an establishment i in strata s, and $w_s = N^s/n^s$ is the weight provided with the data, equal to the inverse probability of being sampled, or the ratio of the population size in strata s to the sample size in strata s. This weight will equal one, for instance, in the census strata. We can confirm that these are indeed the values of the weights provided with the data by comparing the sum of all state and industry aggregates used in Aghion, Burgess, Redding and Zilibotti (2008) with the sum of state industry aggregates created by summing each $\hat{\tau}$ calculated using the unit level data over all state industries. Reassuringly, as is seen in Figure 1, the two aggregates match up almost exactly.

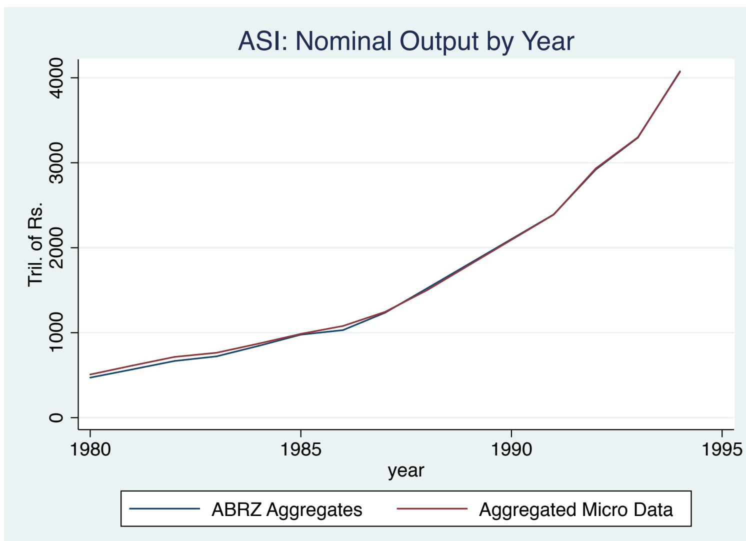

Figure B.1: *Comparison of published aggregates with aggregates constructed from microdata.*

Using the weights provided, we derive a consistent estimator for region industry aggregates within a state as follows. Define a variable y^r_{is} that is equal to y_{is} if that observation i in strata s is in region r, and zero otherwise. The population total in region r is

$$\tau^r = \sum_s \sum_{i=1}^{N_s} y^r_{is} = \sum_s N_s \mu^r_s$$

where $\mu^r_s = \frac{1}{N_s} \sum_{i=1}^{N_s} y^r_{is}$ is the population mean of y^r_{is}. A consistent estimator for μ^r_s is the sample mean $\hat{\mu}_s^r = \frac{1}{n_s}\sum_{i=1}^{n_s} y_{is}^r$. It follows that a consistent estimator for τ^r is

$$\hat{\tau}^r = \sum_s N_s \hat{\mu}_s^r = \sum_s \frac{N_s}{n_s} \sum_{i=1}^{n_s} y_{is}^r = \sum_s w_s \sum_{i=1}^{n_s} y_{is}^r$$

In industry regions with no observed output, we have $\sum_{i=1}^{n_s} y_{is}^r = 0$ for all s and so $\hat{\tau}^r = 0$. It is clear that summing $\hat{\tau}^r$ over all regions r within a state industry will produce $\hat{\tau}$.

Appendix C

Appendix to Chapter 3

C.1 Cocoa Quality

Both international and local cocoa prices vary with quality. Factors contributing to poor quality cocoa are high moisture content, mold, germination, a lack of fermentation and slate, a discoloration signaling poor flavor. There is wide agreement on these standards internationally. For a discussion see CAOBISCO (2002) and for a manual specific to West Africa on how to improve cocoa at the farm level see David (2005). Other dimensions of quality affecting price on the international market are various fair-trade and environmental certifications. Such certification generally requires that beans can be verifiably traced to individual producers. In our market, there is not yet the infrastructure to do such tracing, and so this quality dimension does not apply.

Table C.1 shows the average quality and wholesale prices of cocoa bags from the experiment, before the November fall in the international price. As can be seen, moisture content has the highest price elasticity—price falls by 0.32% with a one percentage point increase in moisture. Moisture is an important variable in our market, because wet cocoa rots in storage, destroying value. At an average 11% moisture content, cocoa in our market is substantially wetter than export grade, which requires a maximum moisture content of 7%. For this reason, many exporters maintain large drying facilities. There is an efficiency cost to this organizational structure, as some cocoa that is not dried at the farm gate will be lost to rot in transport.

In our grading system, inspectors from our research team with local language skills stayed in the warehouses of wholesalers and tested a sample of 50 beans from each bag of cocoa as it

Table C.1: *Cocoa Quality*

Defect	Average per shipment	Price elasticity	Average per pound price by tercile of defect (Le.) 1	2	3
Moisture Content	11%	-0.32%	3,384	3,297	3,263
Mold	2%	-0.02%	3,308	3,353	3,241
Germinated	3%	-0.01%	3,309	3,313	3,298
Under-fermented	15%	-0.02%	3,345	3,333	3,228
Slate	7%	-0.01%	3,323	3,304	3,279

Notes: Data from 916 treatment and control transactions. Elasiticty gives the percentage reduction in price for a 1 percentage point increase in the defect.

arrived. Moisture was measured using Dickey John MiniGAC moisture meters, two of which were generously donated by the manufacturer. Other defects were spotted by eye, after cracking beans open with a knife. Grade A beans have no more than average 11.5% moisture, no more than 2% mold (1 bean of 50), and no less than 72% beans with no defect (36 beans of 50). Grade B beans have no more than 22% moisture, 4% mold (2 beans of 50) and no less than 52% good beans (27 beans of 50). Grade C applies to any bean failing to be grade A or B. At baseline, quantities supplied by traders were approximately one third of each.